Universidad de Alcalá

SPACE WEATHER GROUP

SMOS solar radio observations and their application to Space Weather

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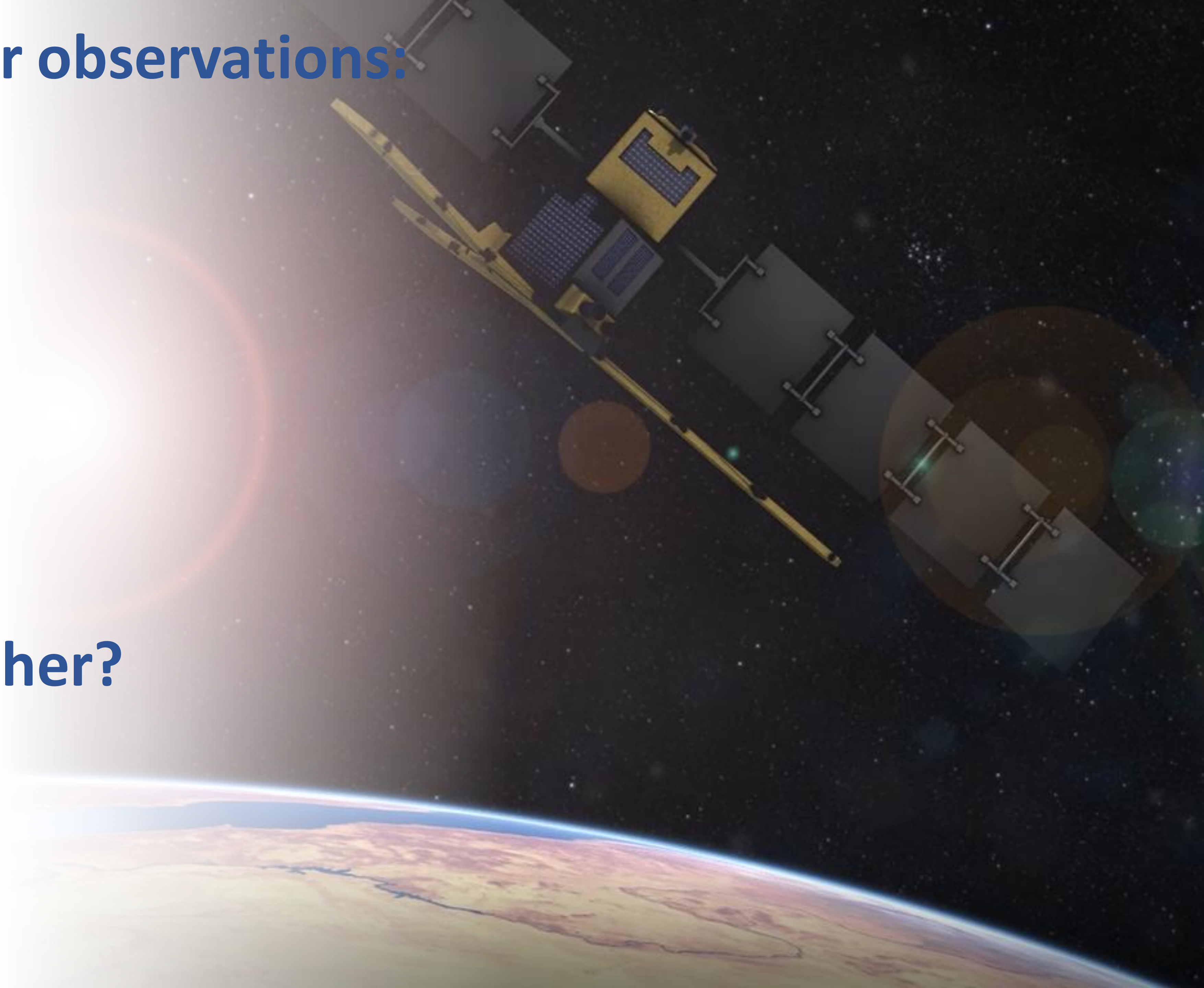
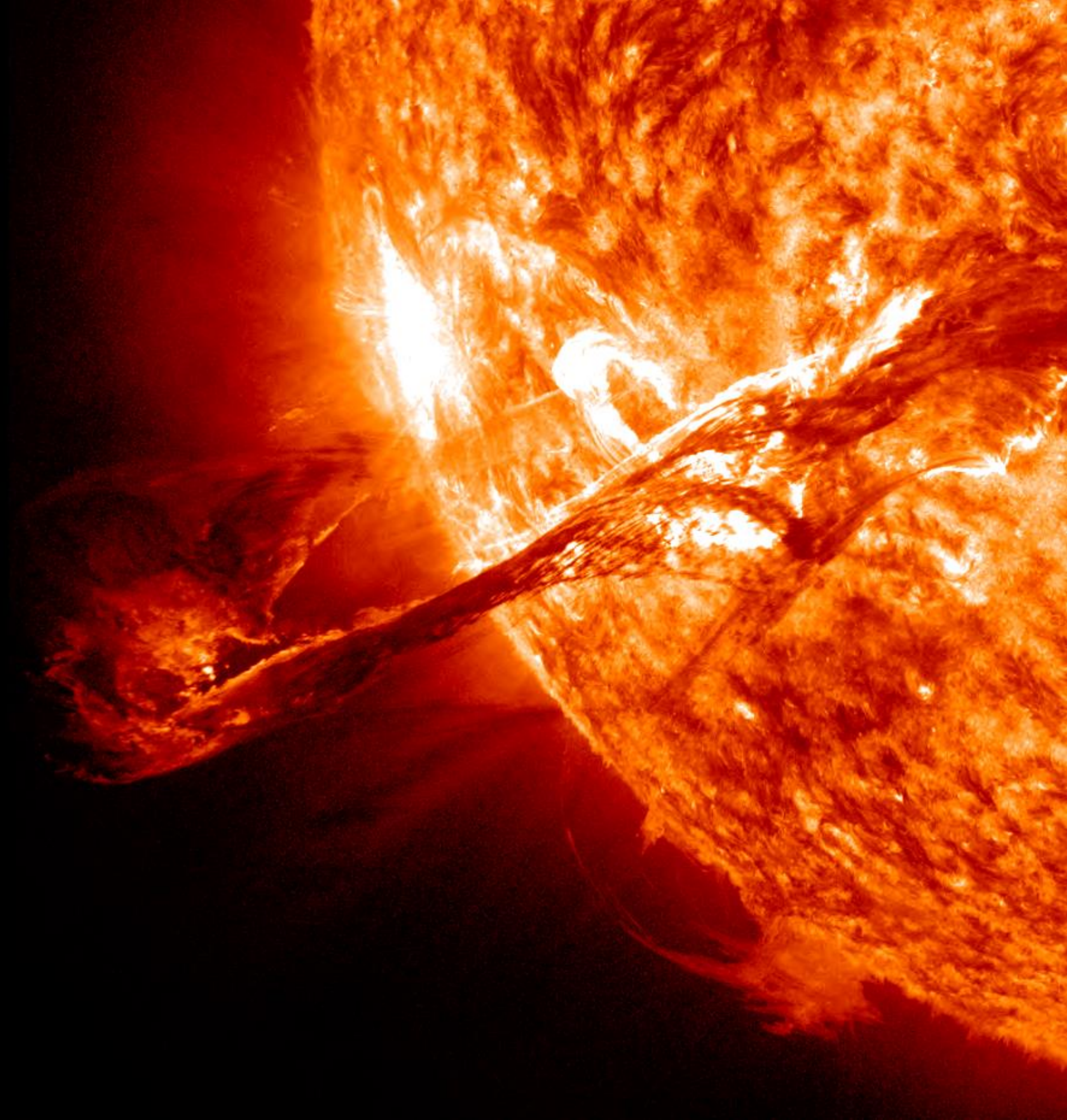
SMOS 1.4 GHz solar observations:

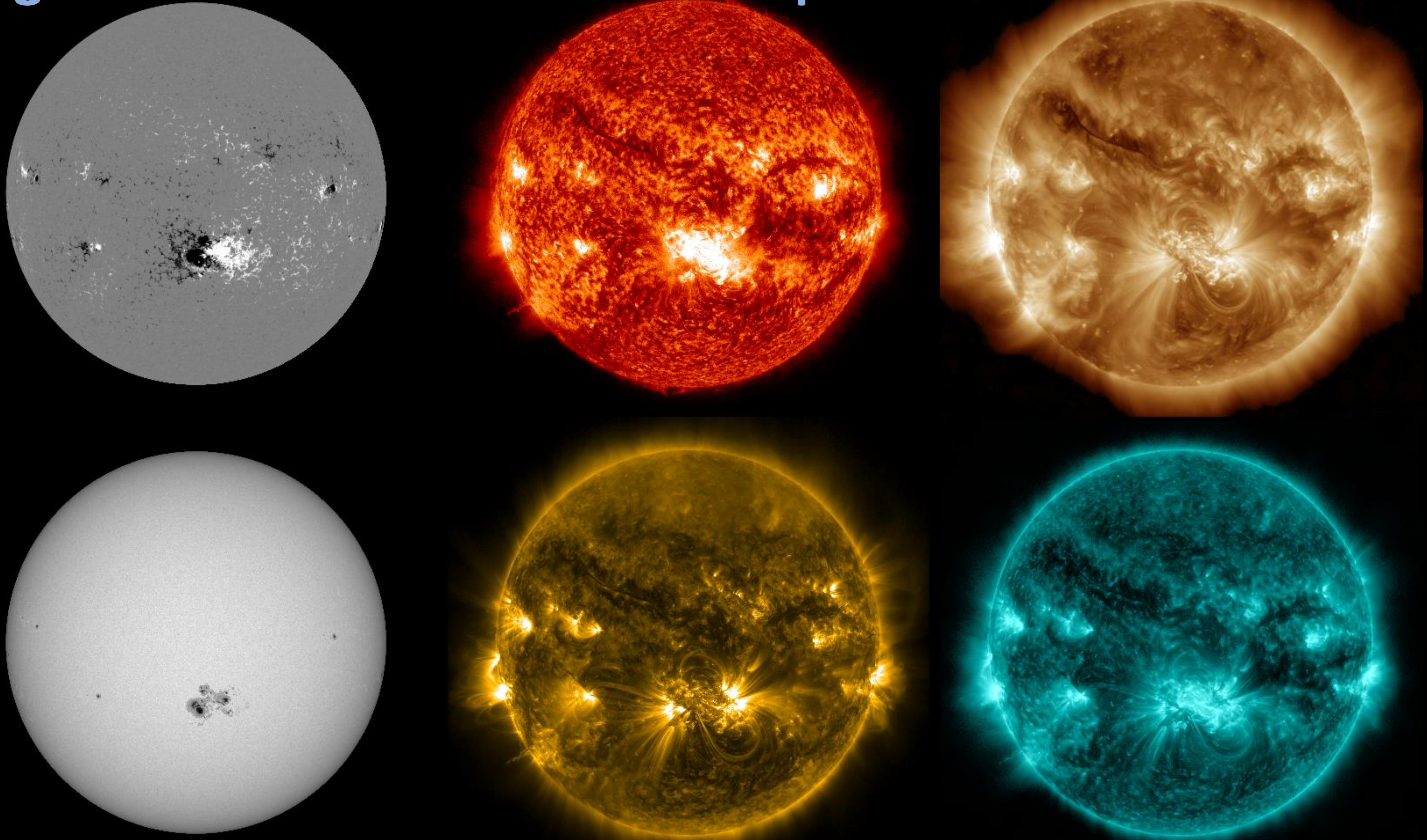
- How good?
- What for?
- Why even bother?



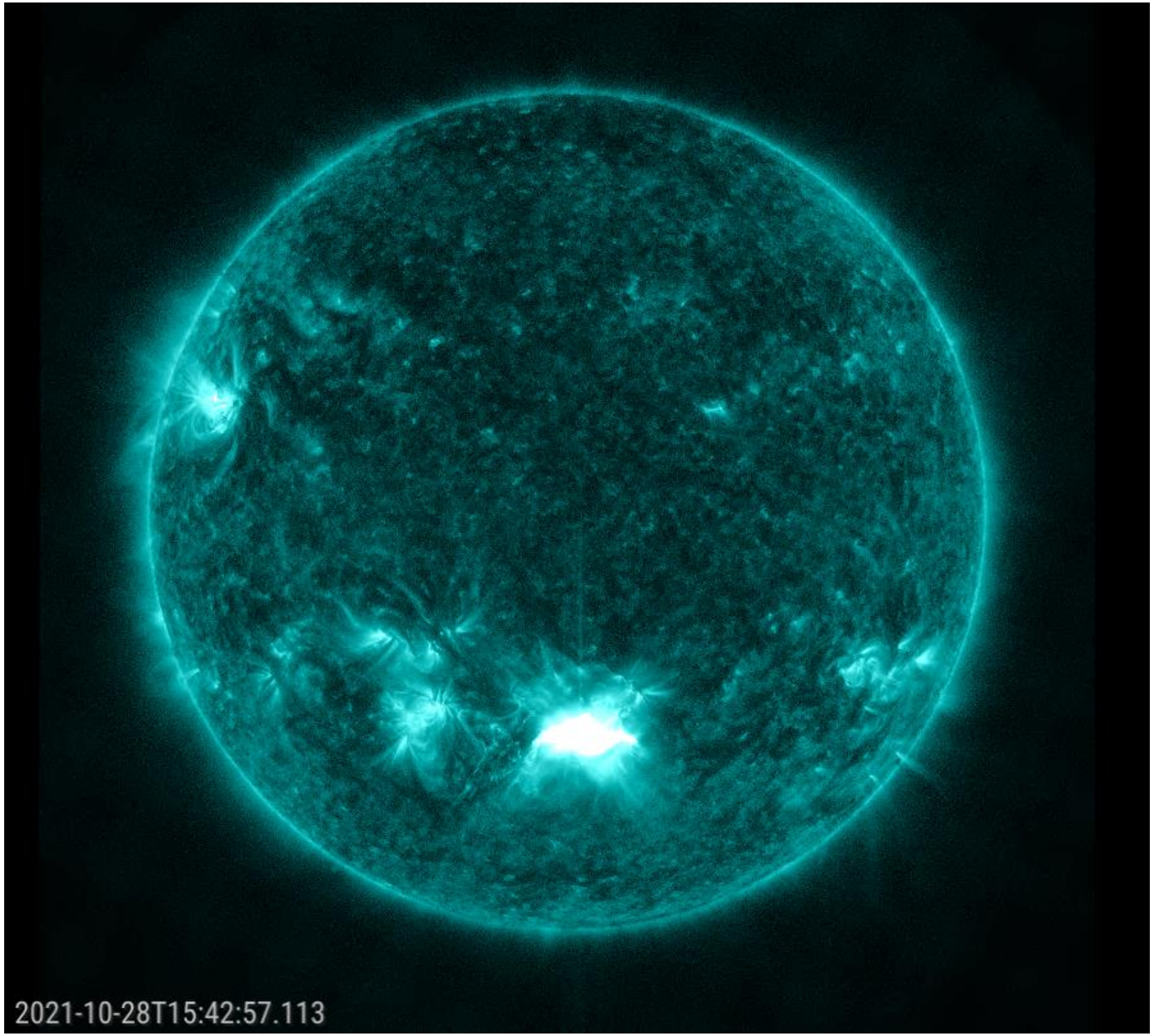
Very brief introduction to solar activity

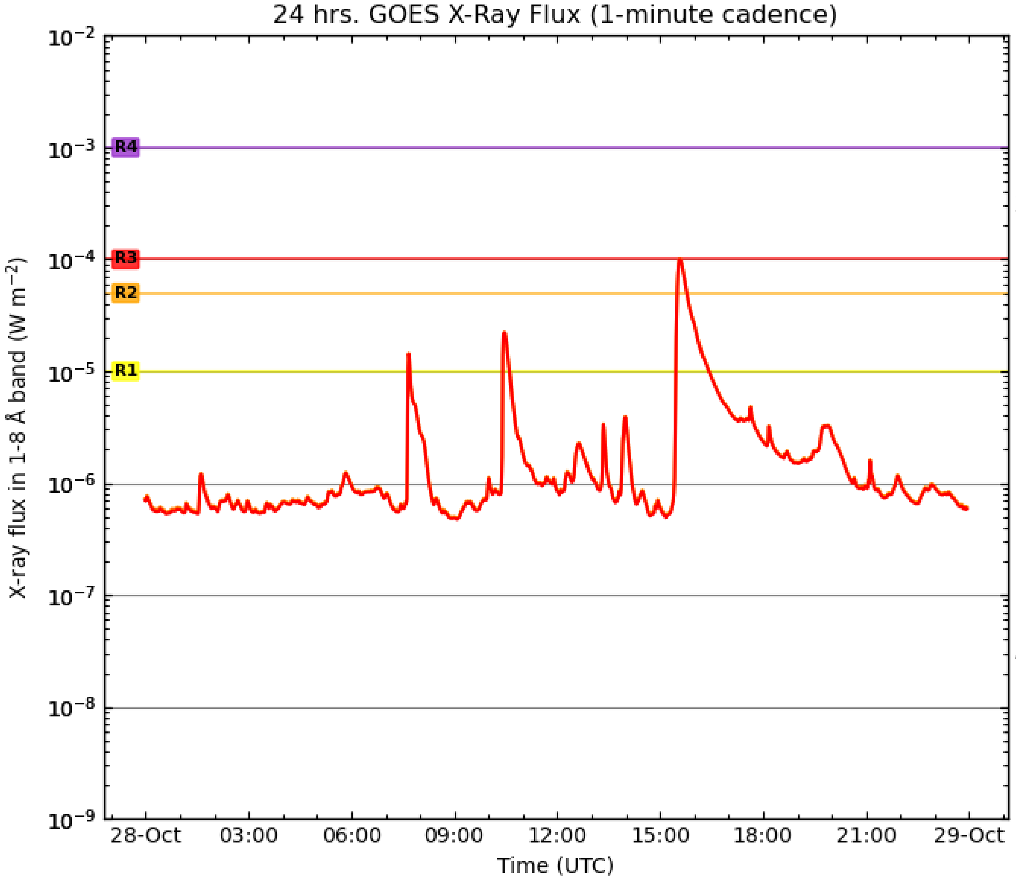


Magnetic fields in the solar atmosphere

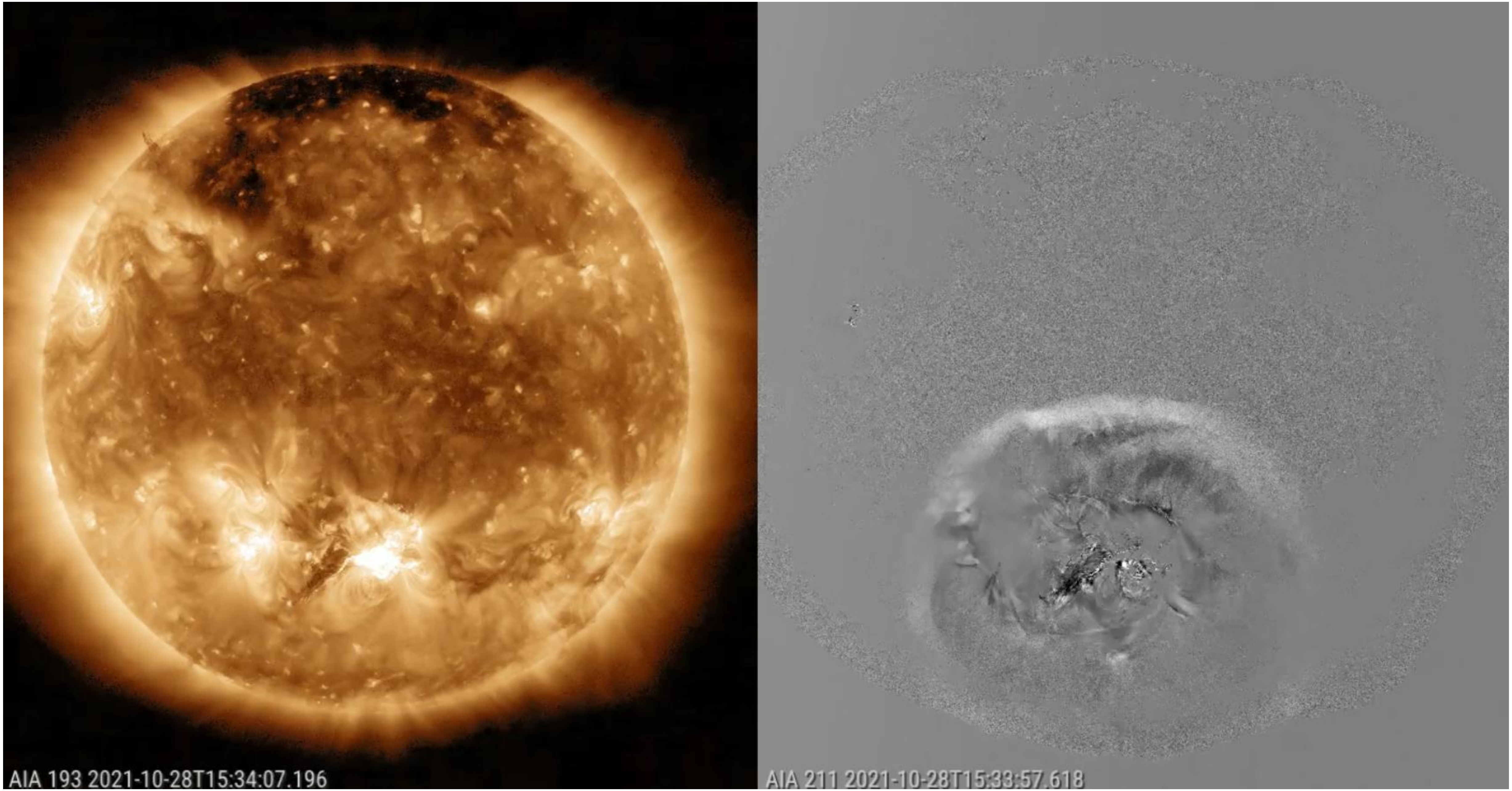


Solar flares

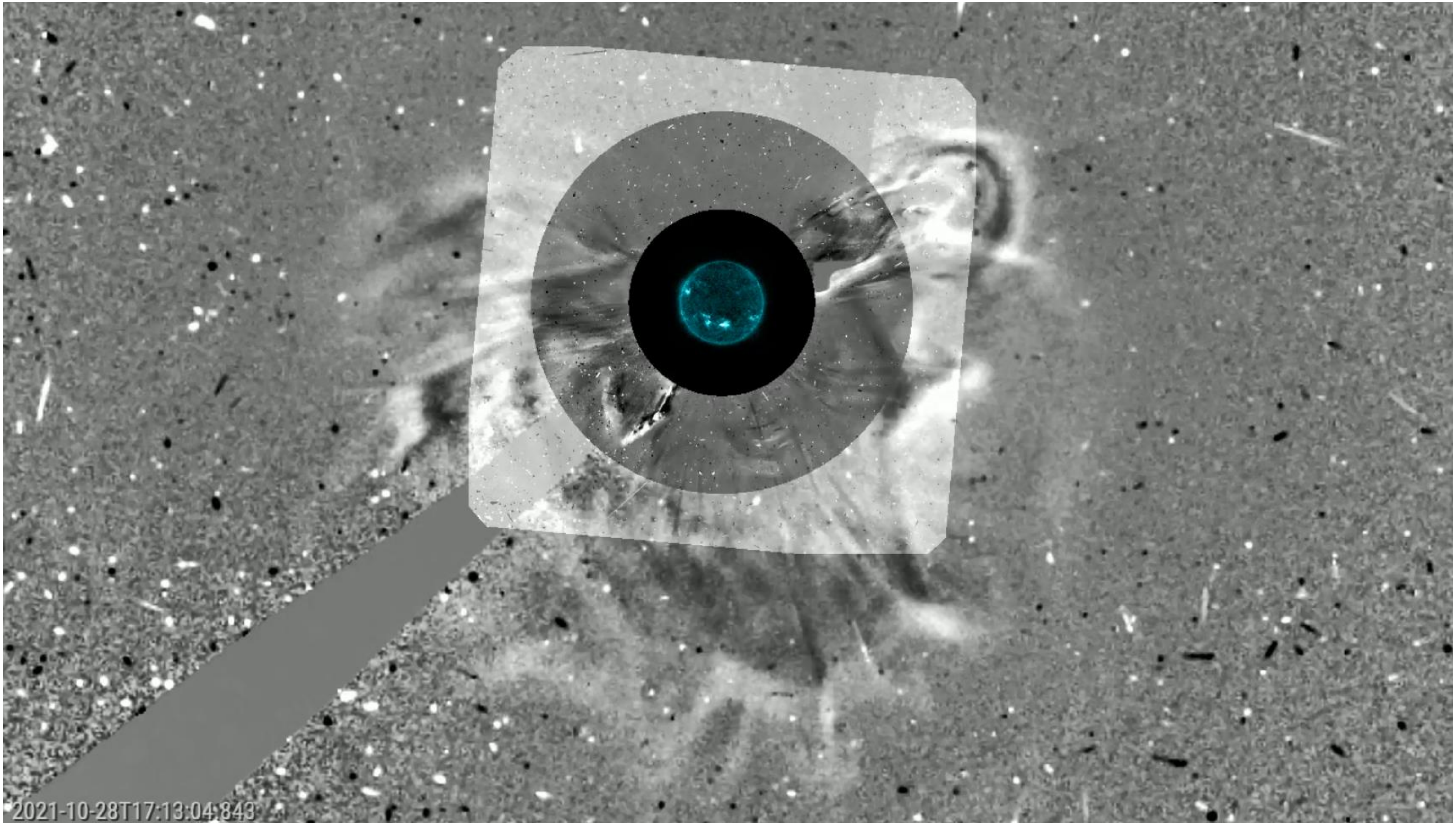




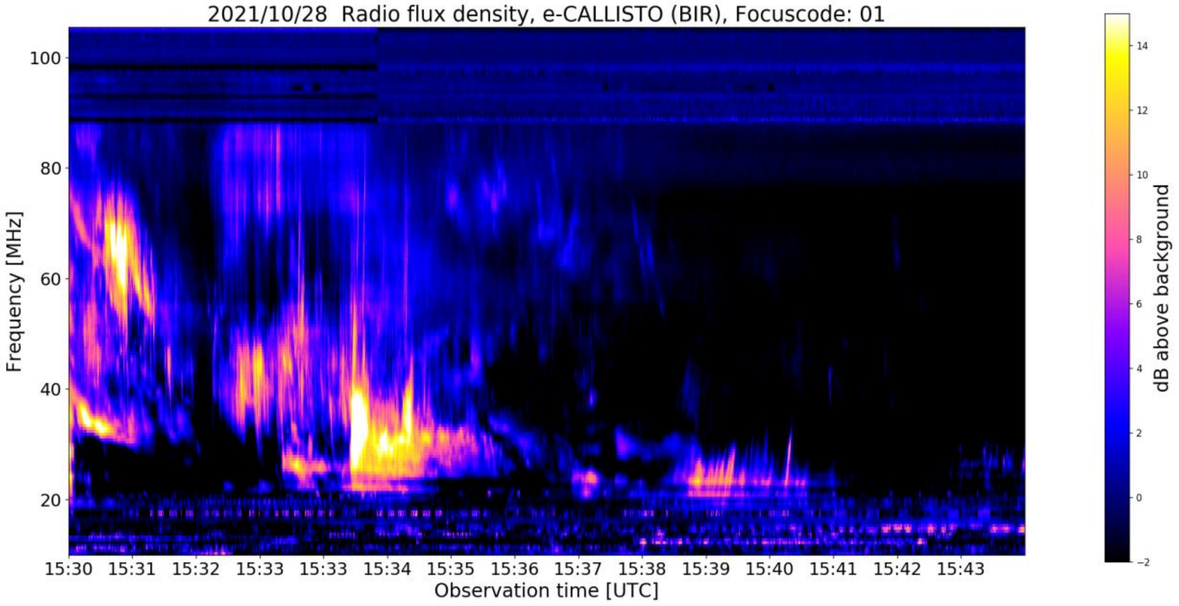
Mass motions

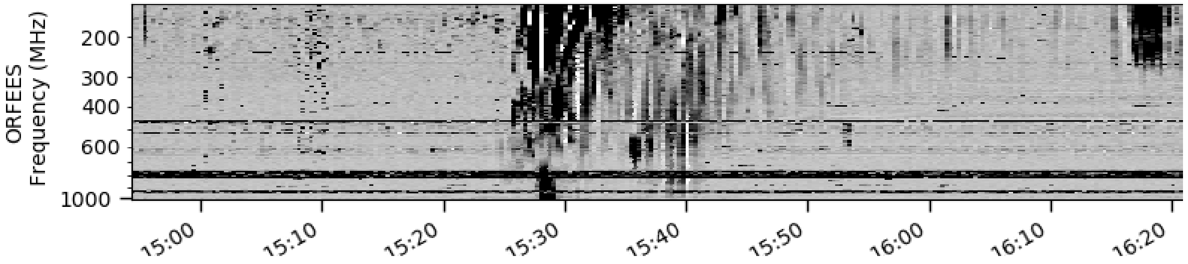


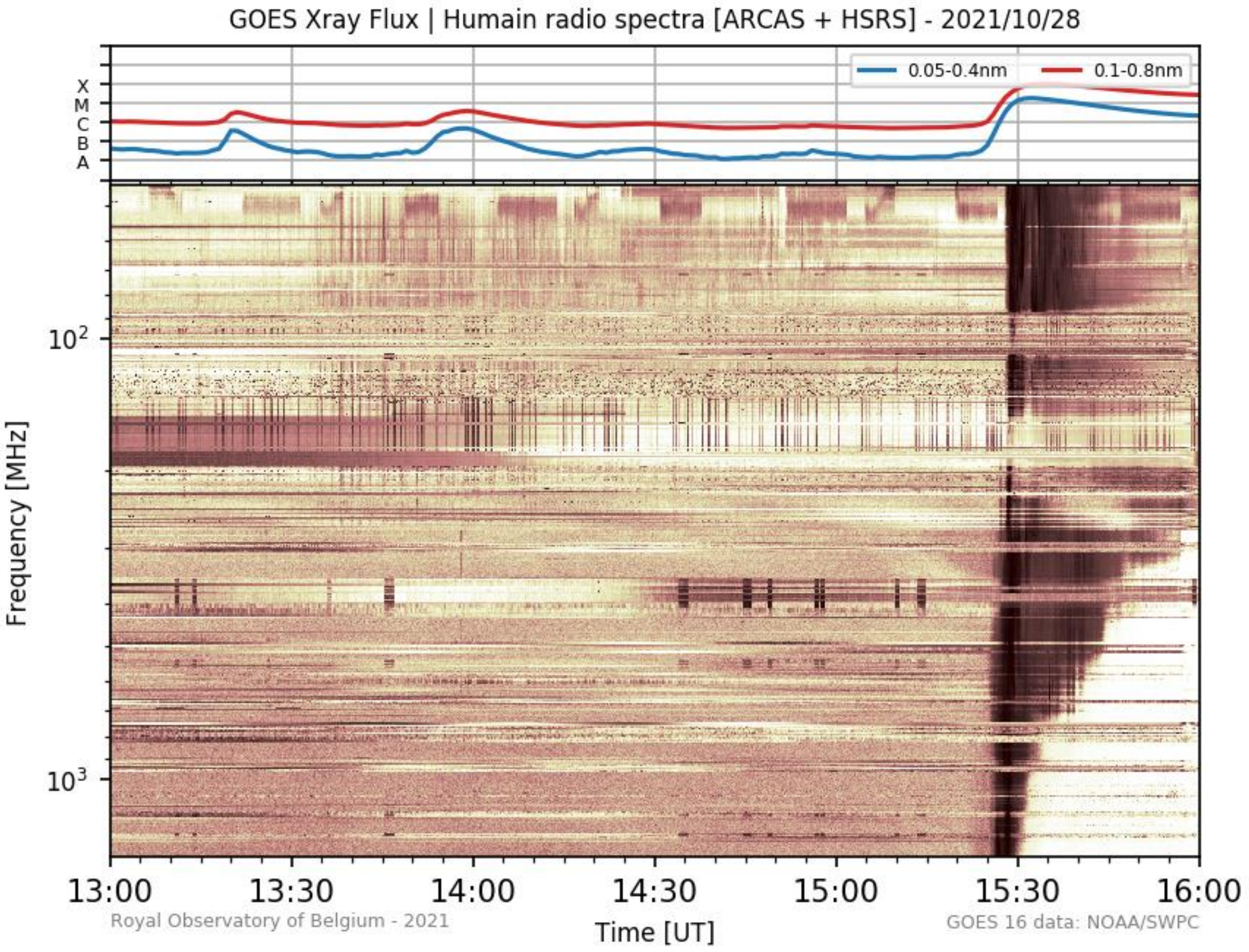
Coronal mass ejections (CME)



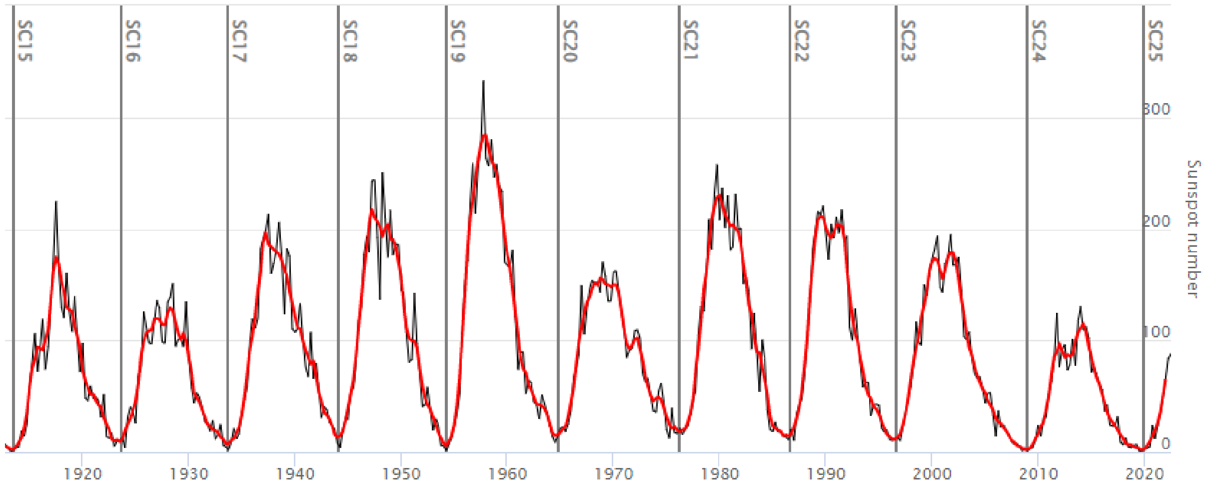
Solar radio bursts (SRB)

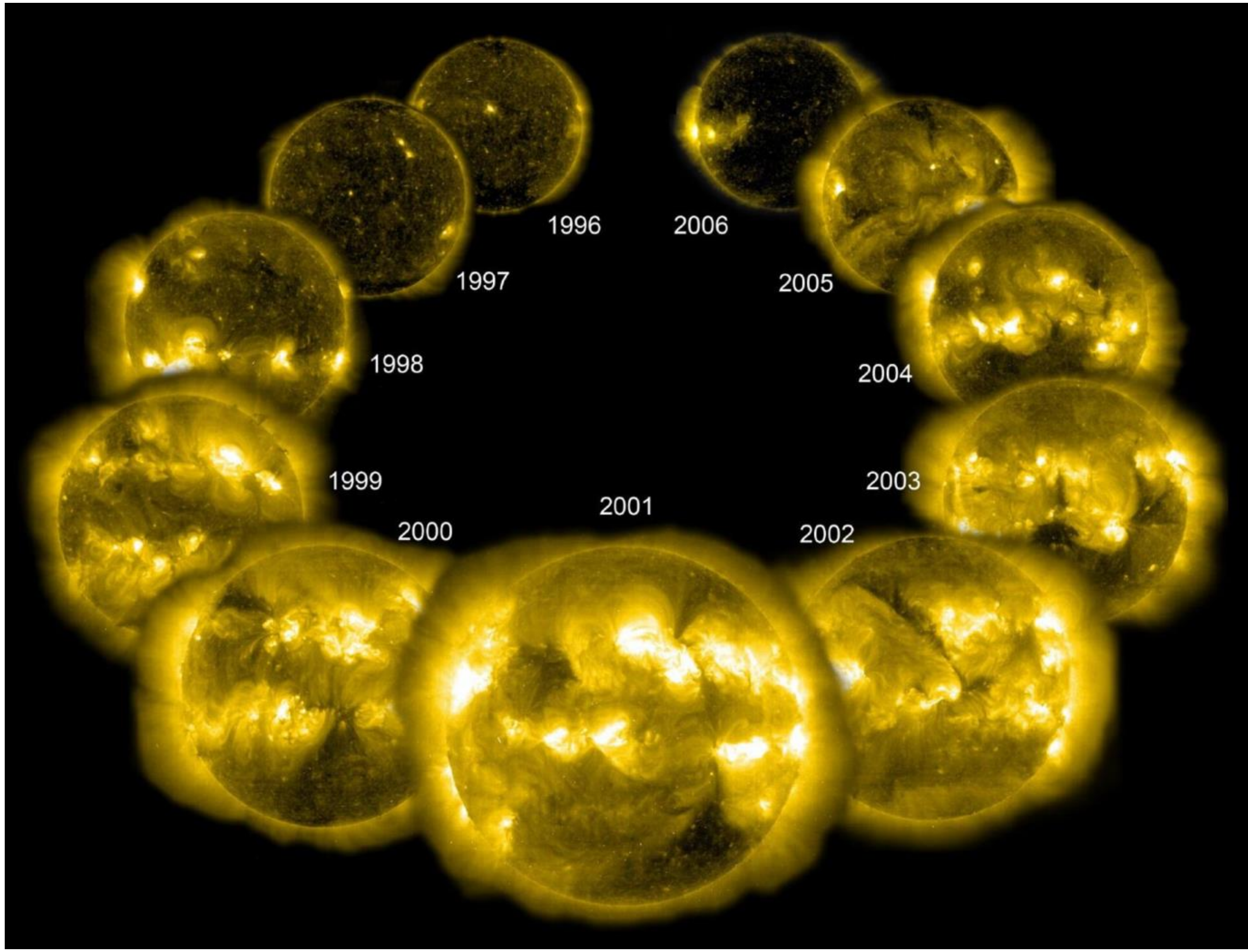




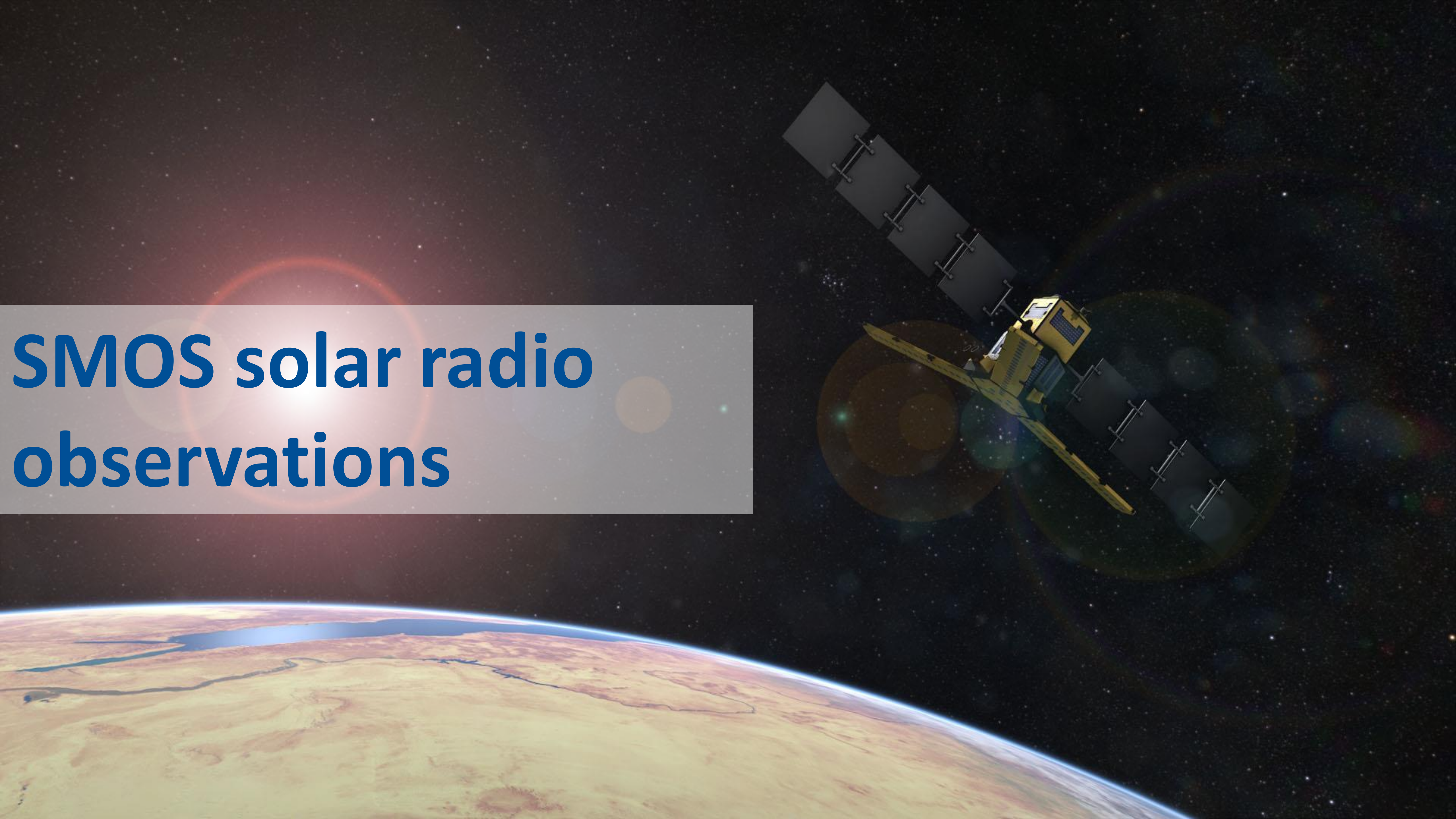


Solar activity cycle





SMOS solar radio observations



Validation SMOS solar data

Byproduct of the Sun B_T corrector

Flores-Soriano et al. (2021). https://doi.org/10.1029/2020SW002649

Version 621:

- All data from 2010 to 2019
- Only when Sun in front of the antenna
- Only intensity, not polarization

Versions 722, 724, 750:

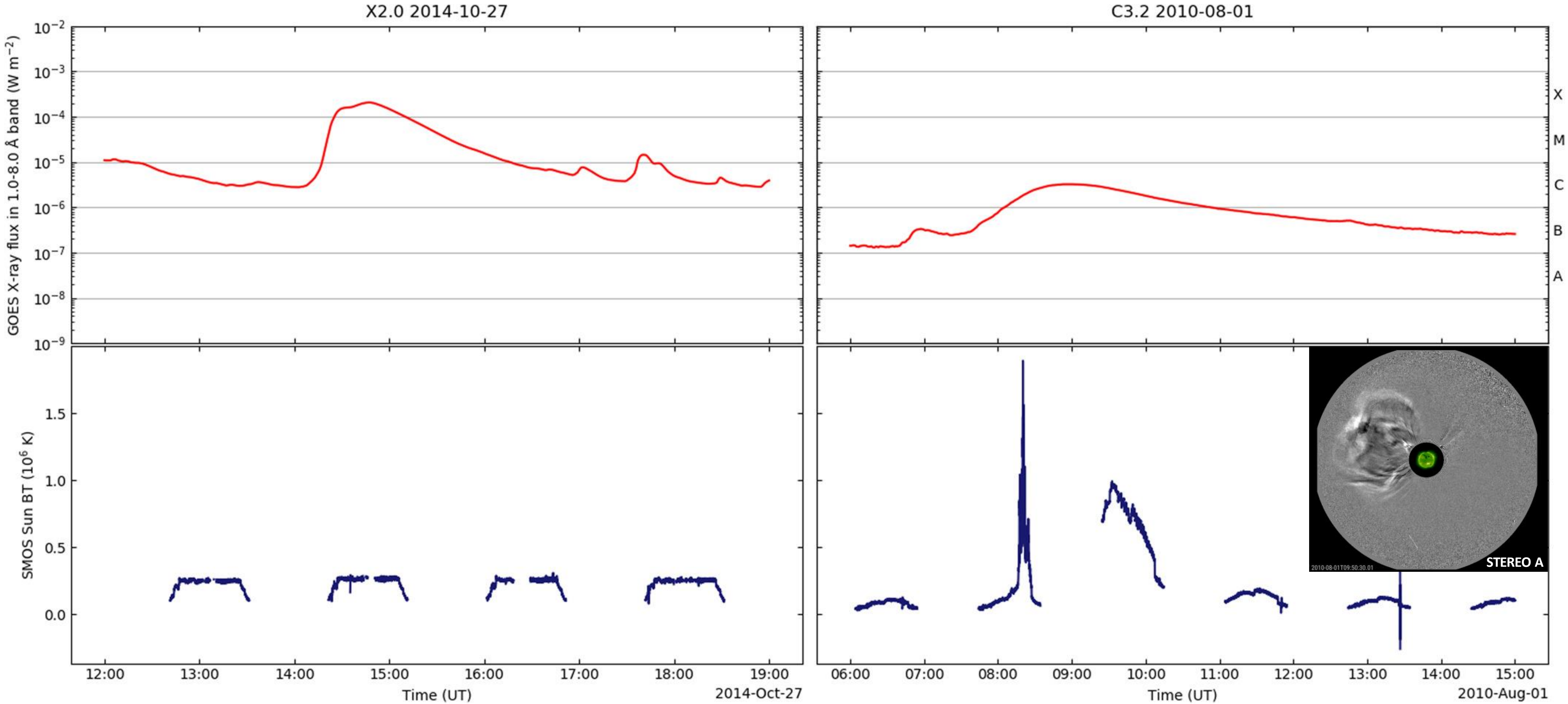
- Just for a handful of events
- Also when the Sun is at the back of the antenna
- Full polarization

Dedicated solar flux product

Pre-validation prototype:

- 20+ events
- For algorithm fine-tuning before full validation

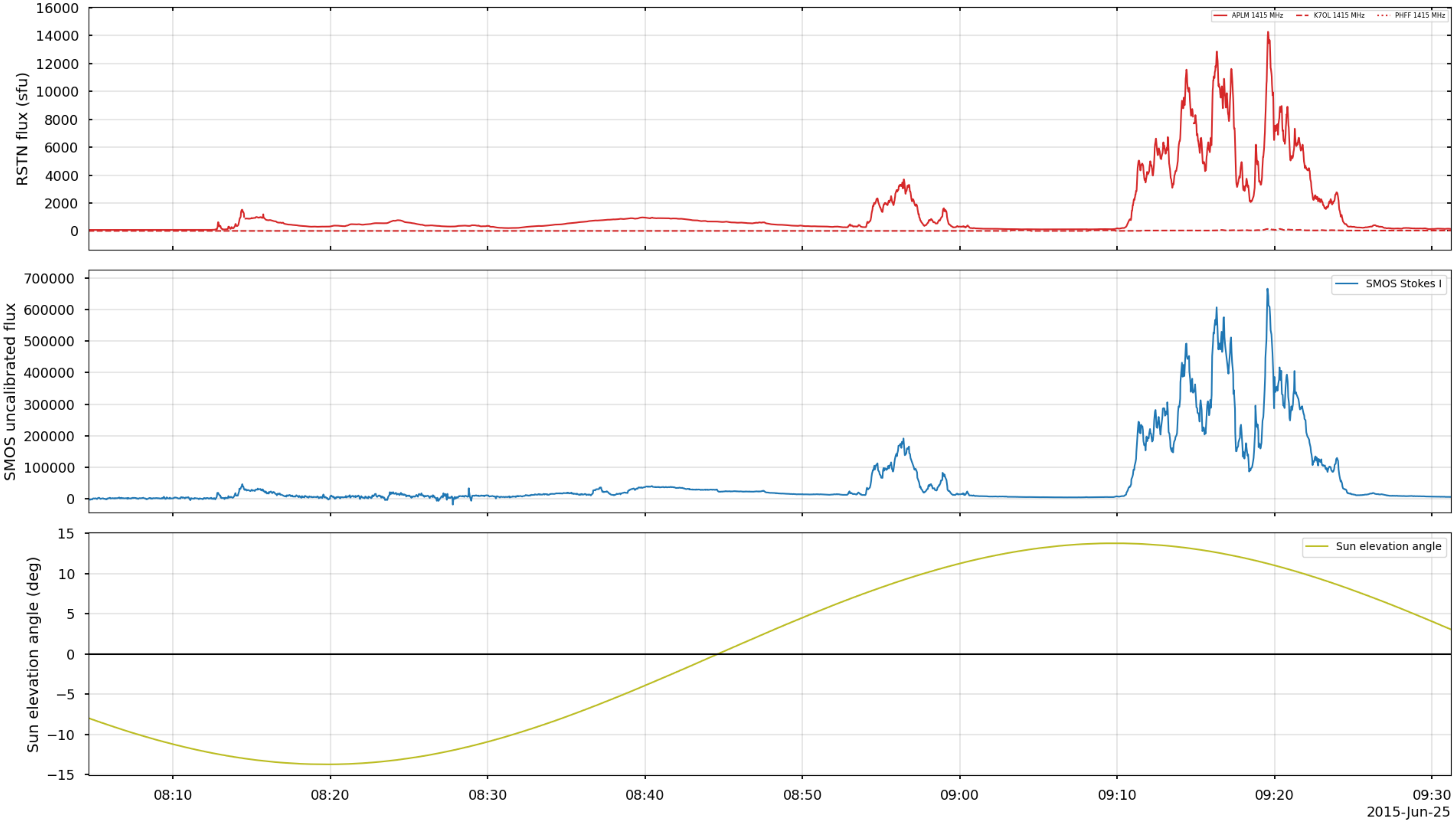
Detection of solar radio bursts



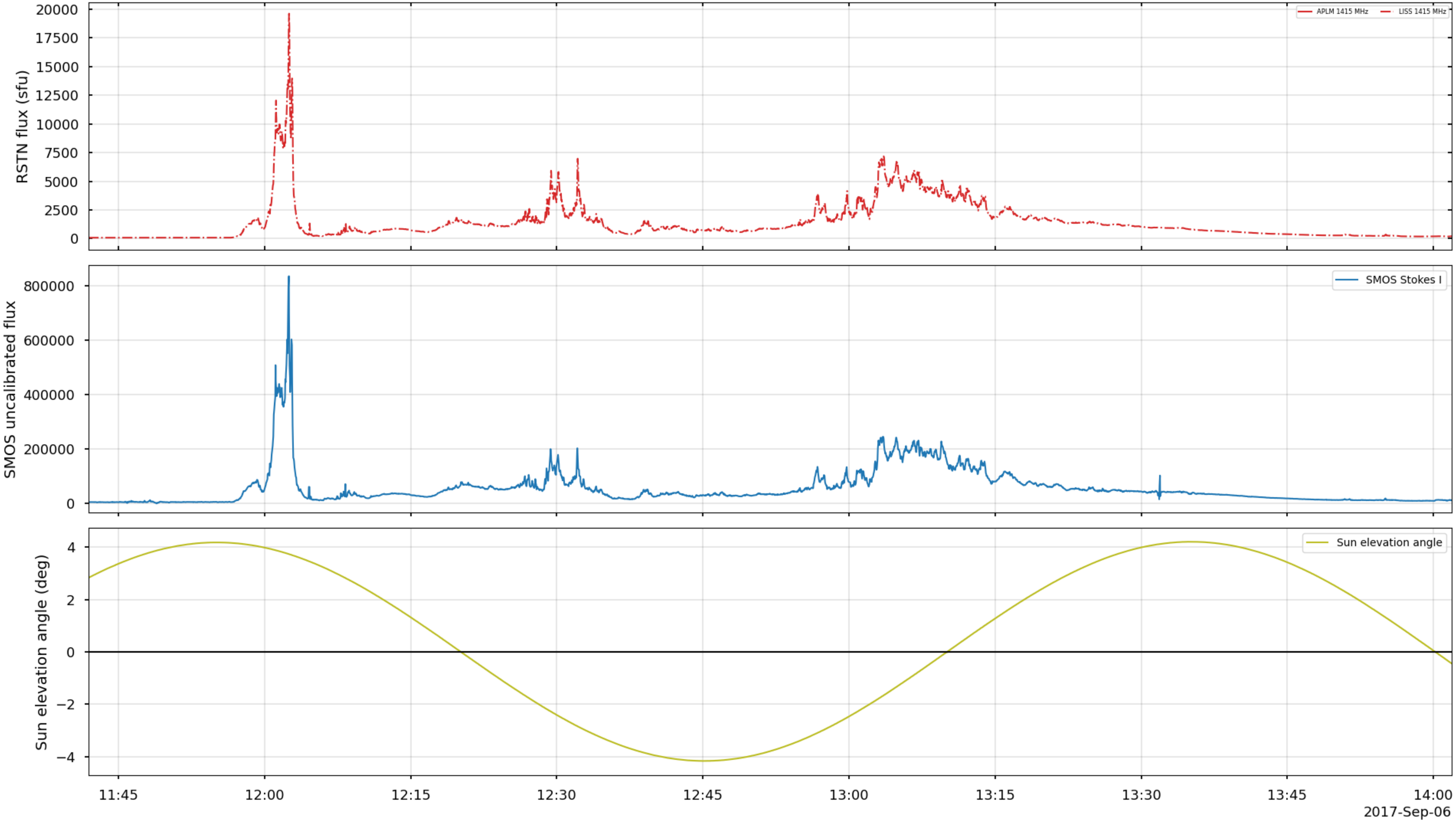
89 SRBs found in the period 2010-2019

- All during flares associated with CMEs
- Missing approx. 30 when the Sun was behind the antenna (older version of data processor)

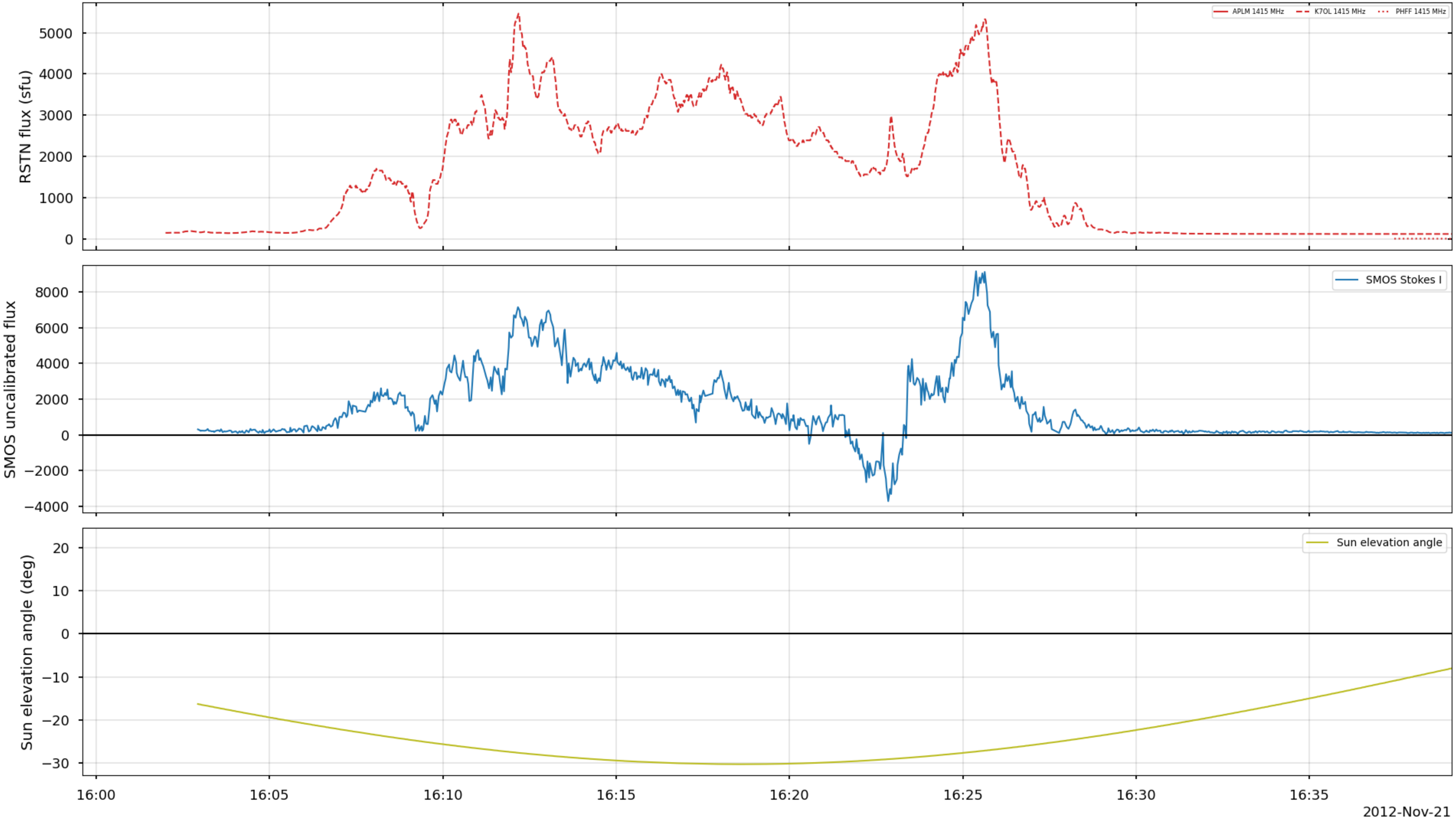
SRB comparison with RSTN



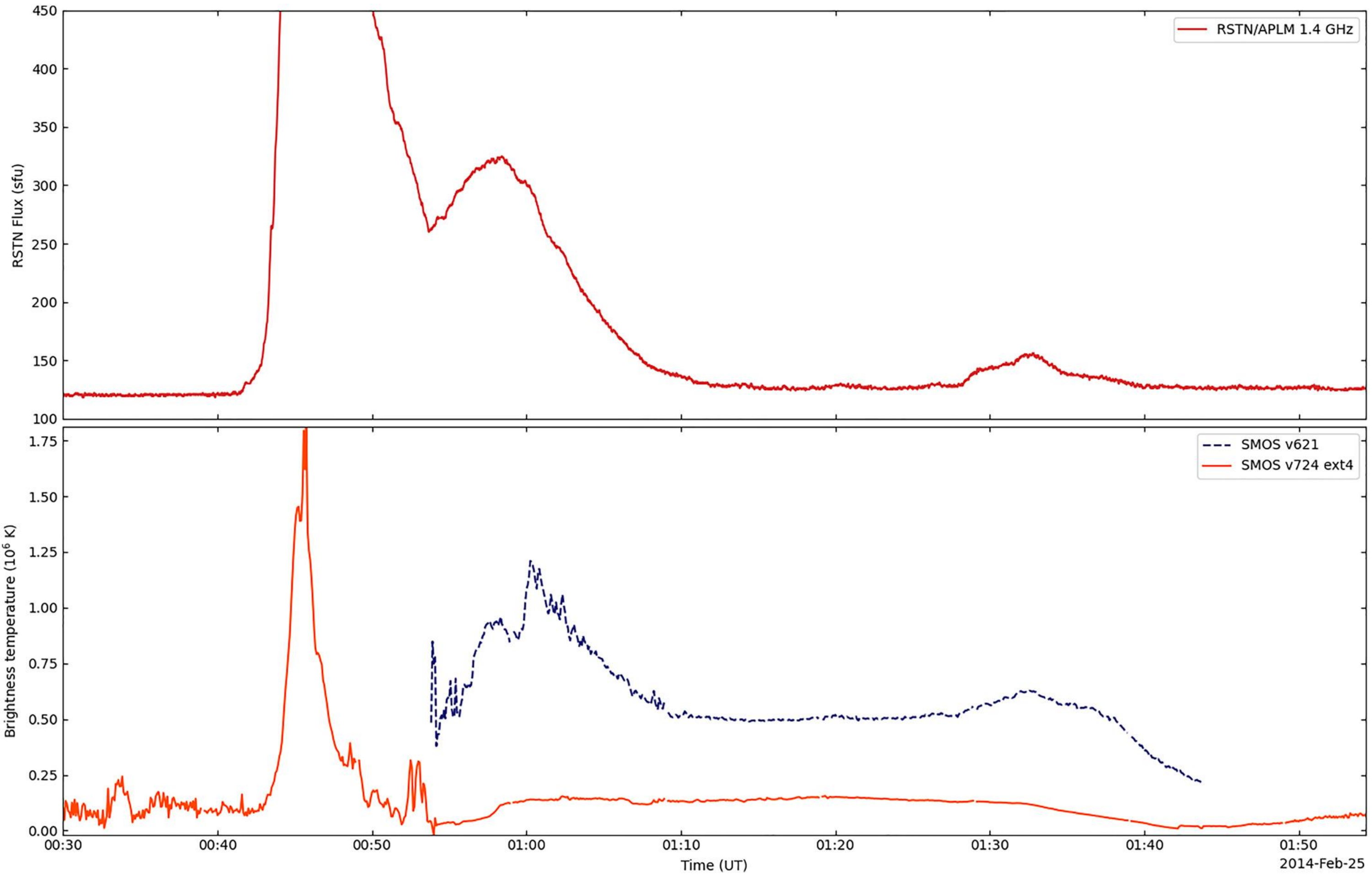
SRB comparison with RSTN – Low elevation angle



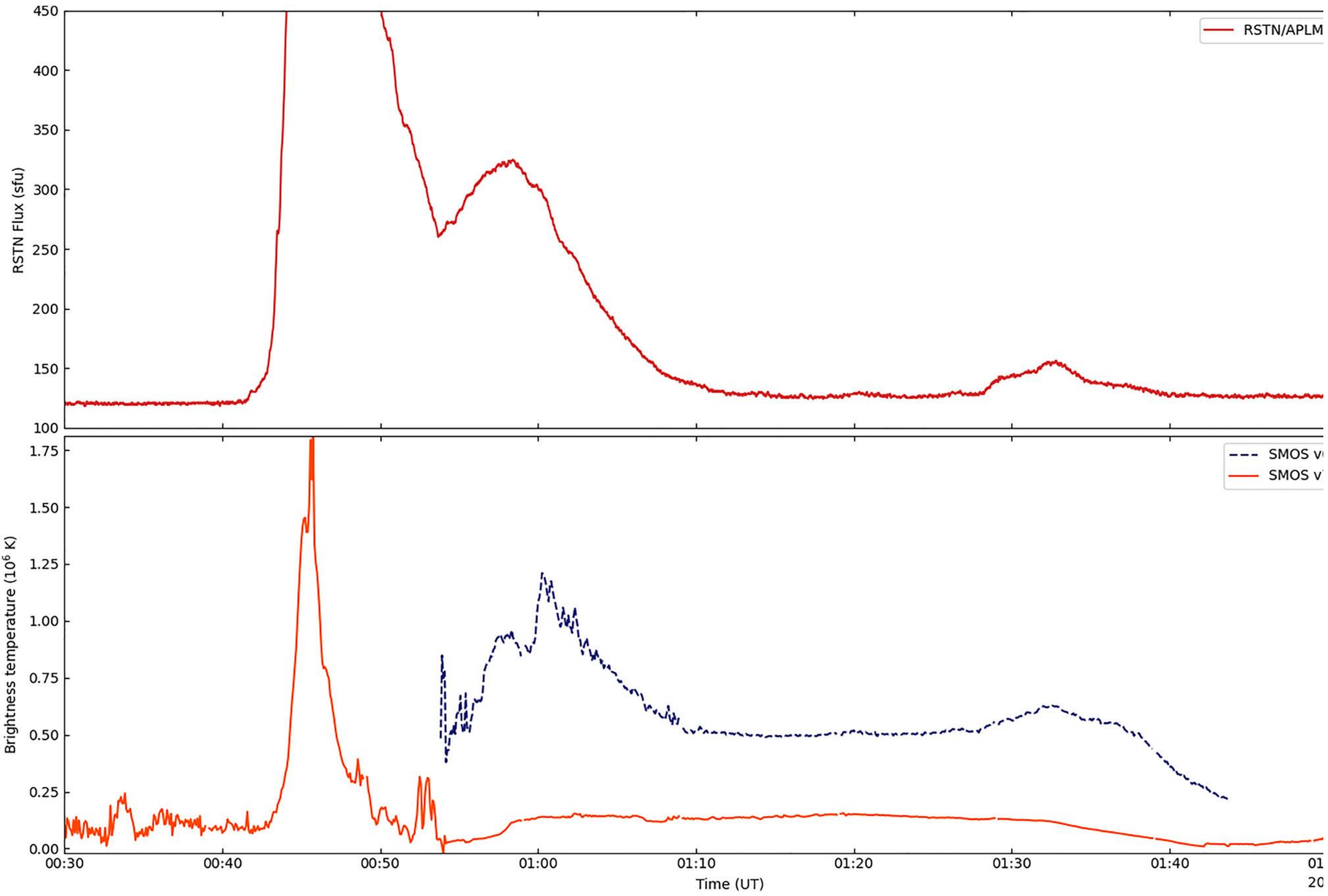
SRB comparison with RSTN – Worst case scenario

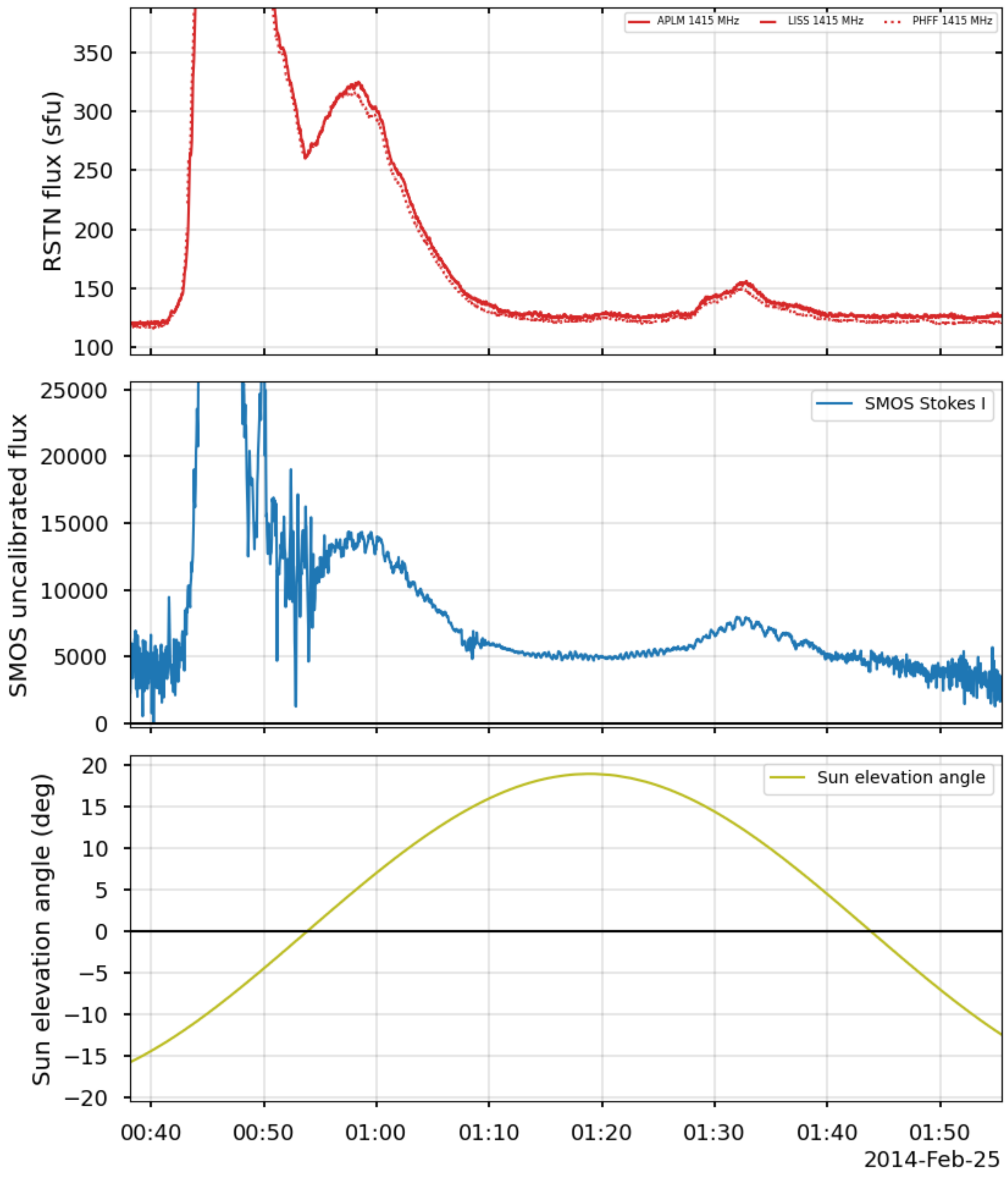


Sensitivity comparison with RSTN

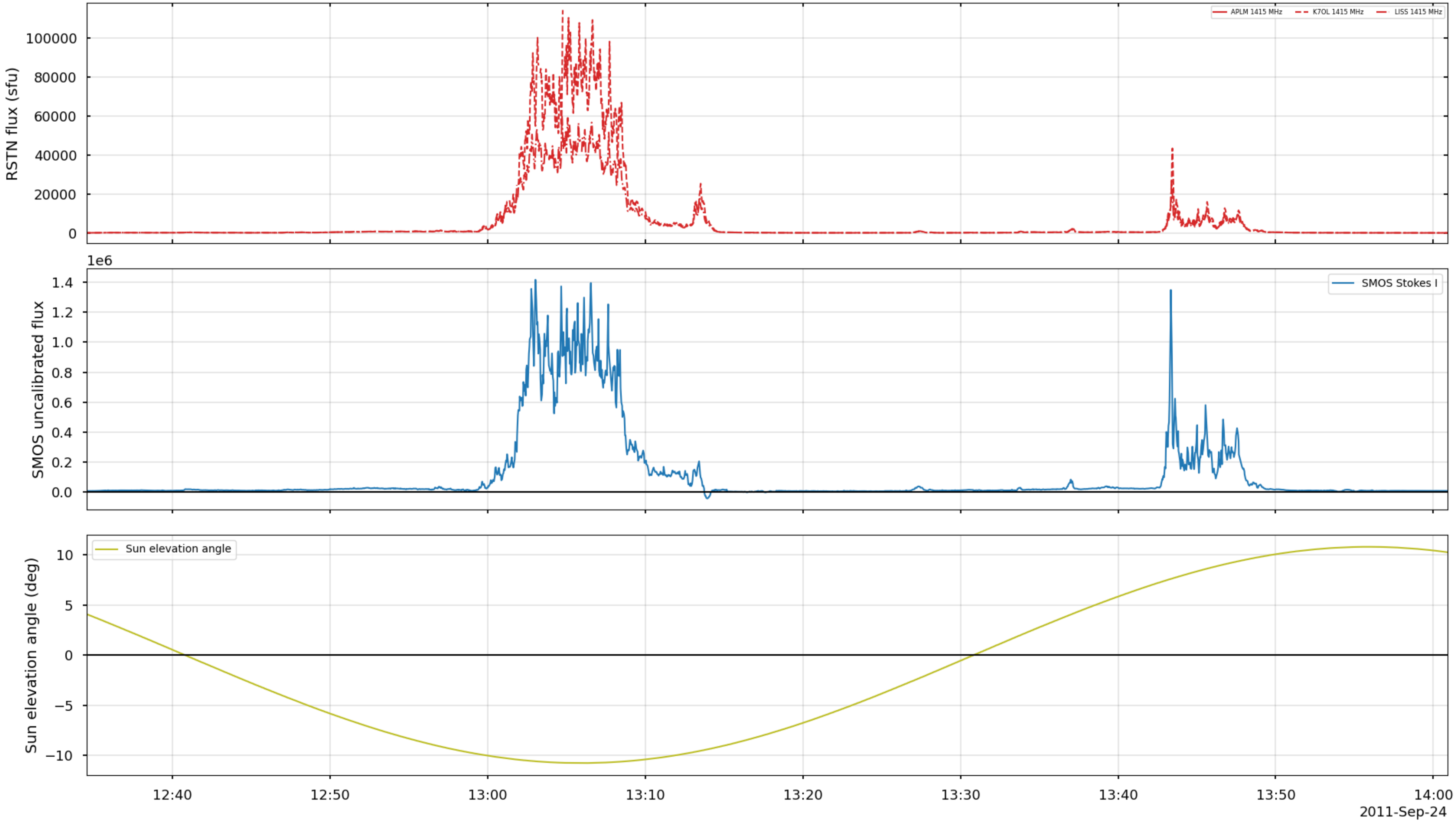


Sensitivity comparison with RSTN



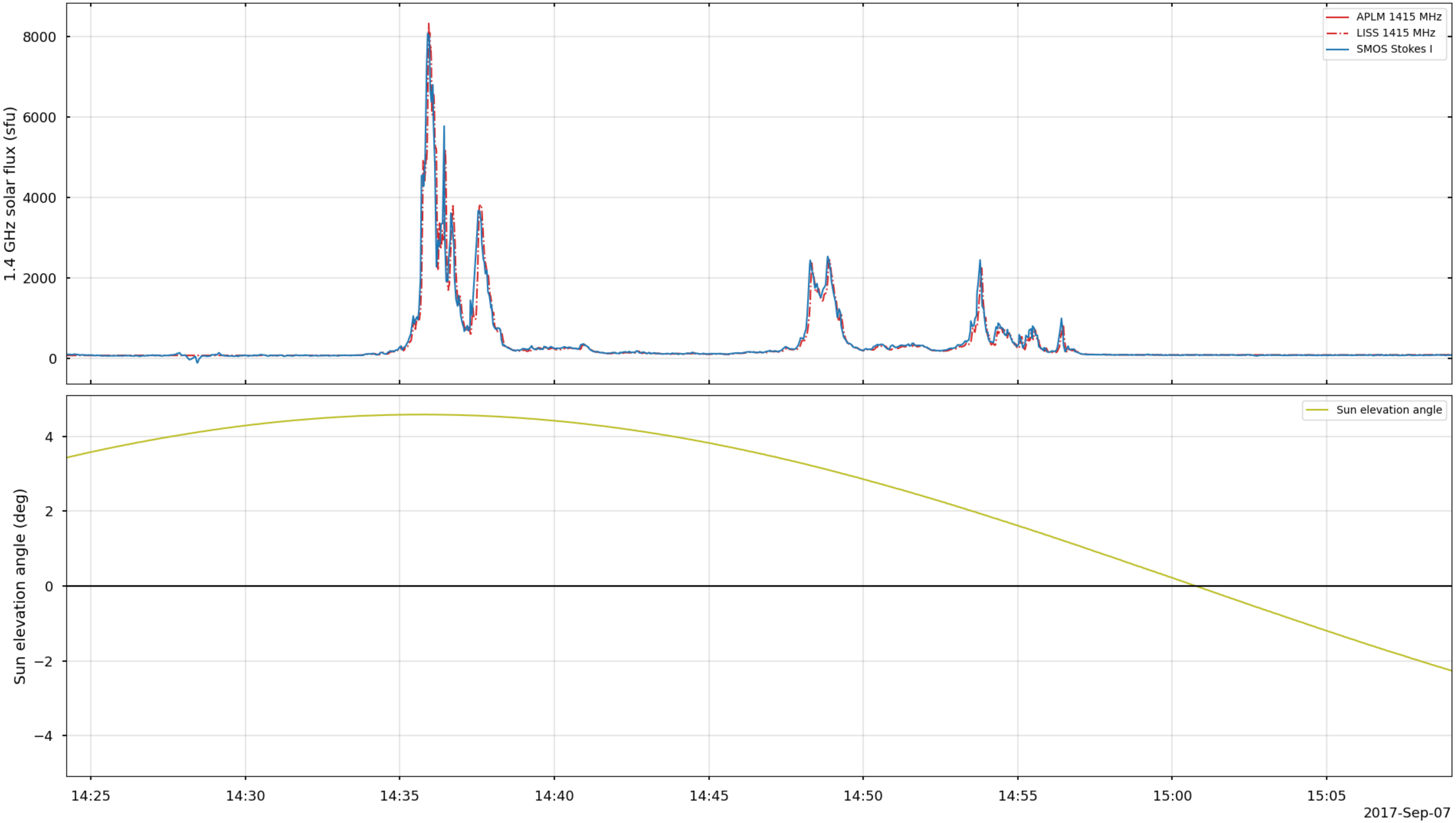


Saturation

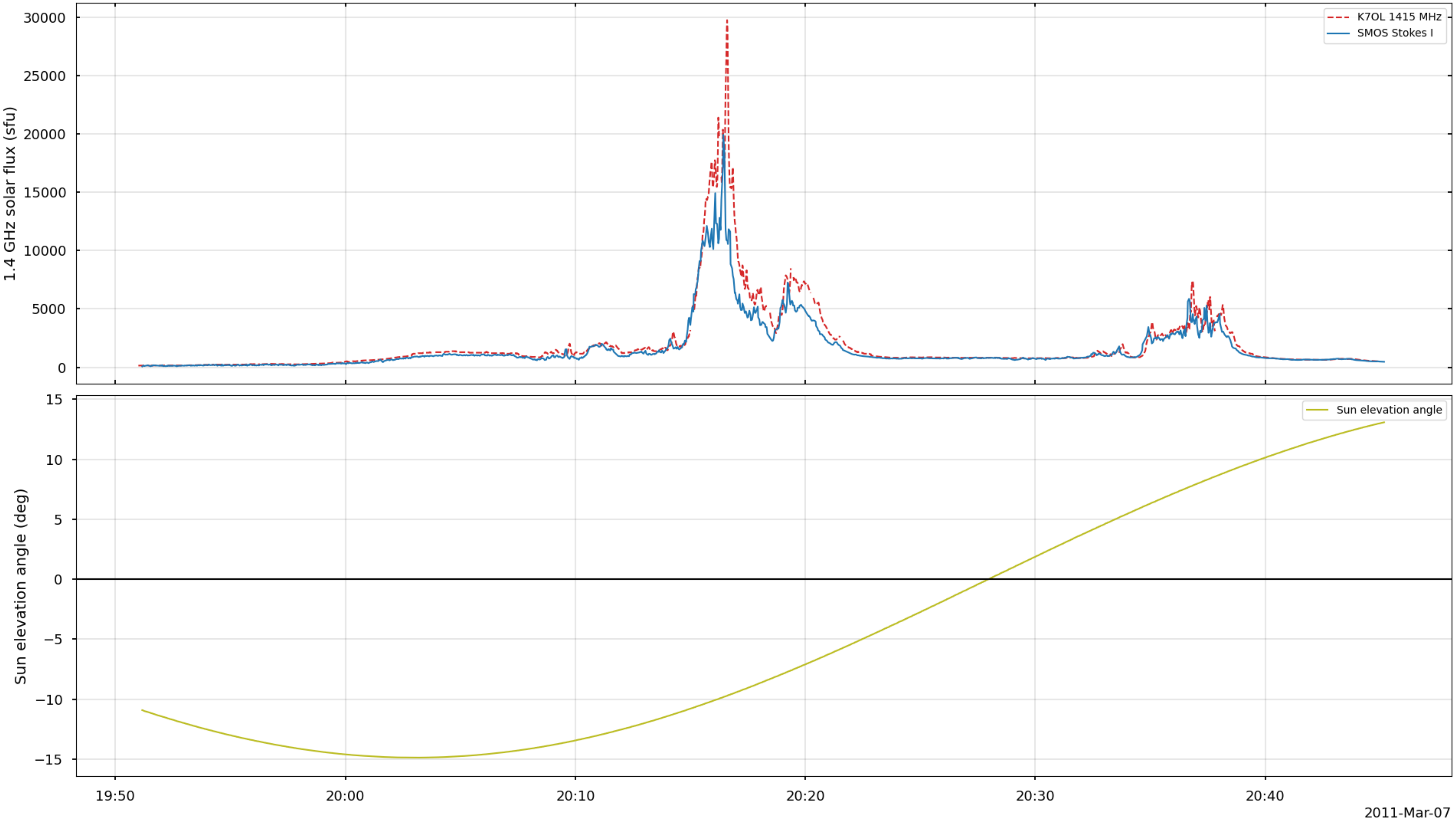


APLM 1415 MHz
K7OL 1415 MHz
LISS 1415 MHz
RSTN flux (sfu)
100000
80000
60000
40000
20000
0
1e6
SMOS Stokes I
SMOS uncalibrated flux
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Sun elevation angle
Sun elevation angle (deg)
10
5
0
−5
−10
12:40
12:50
13:00
13:10
13:20
13:30
13:40
13:50
14:00
2011-Sep-24

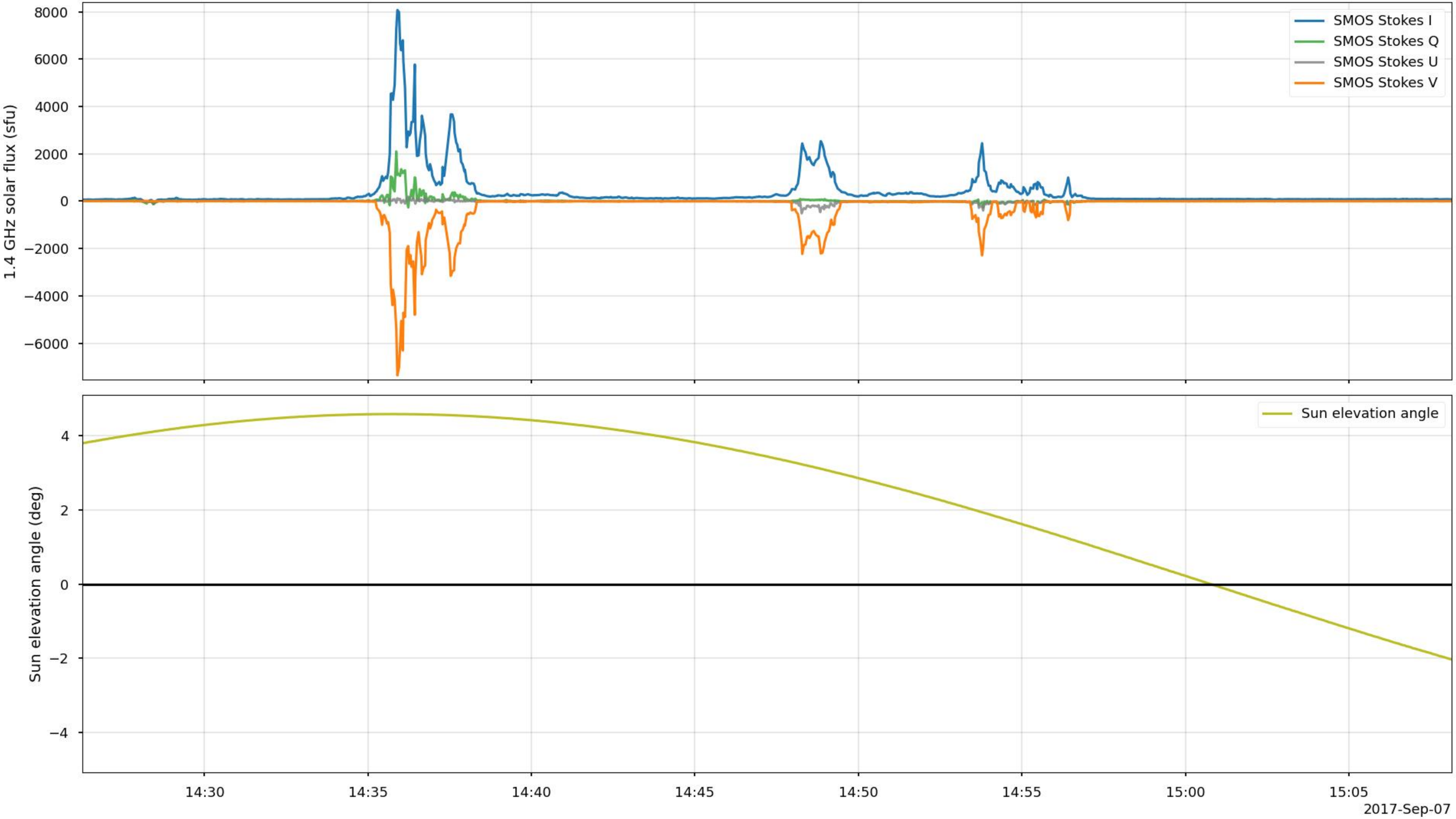
Calibration



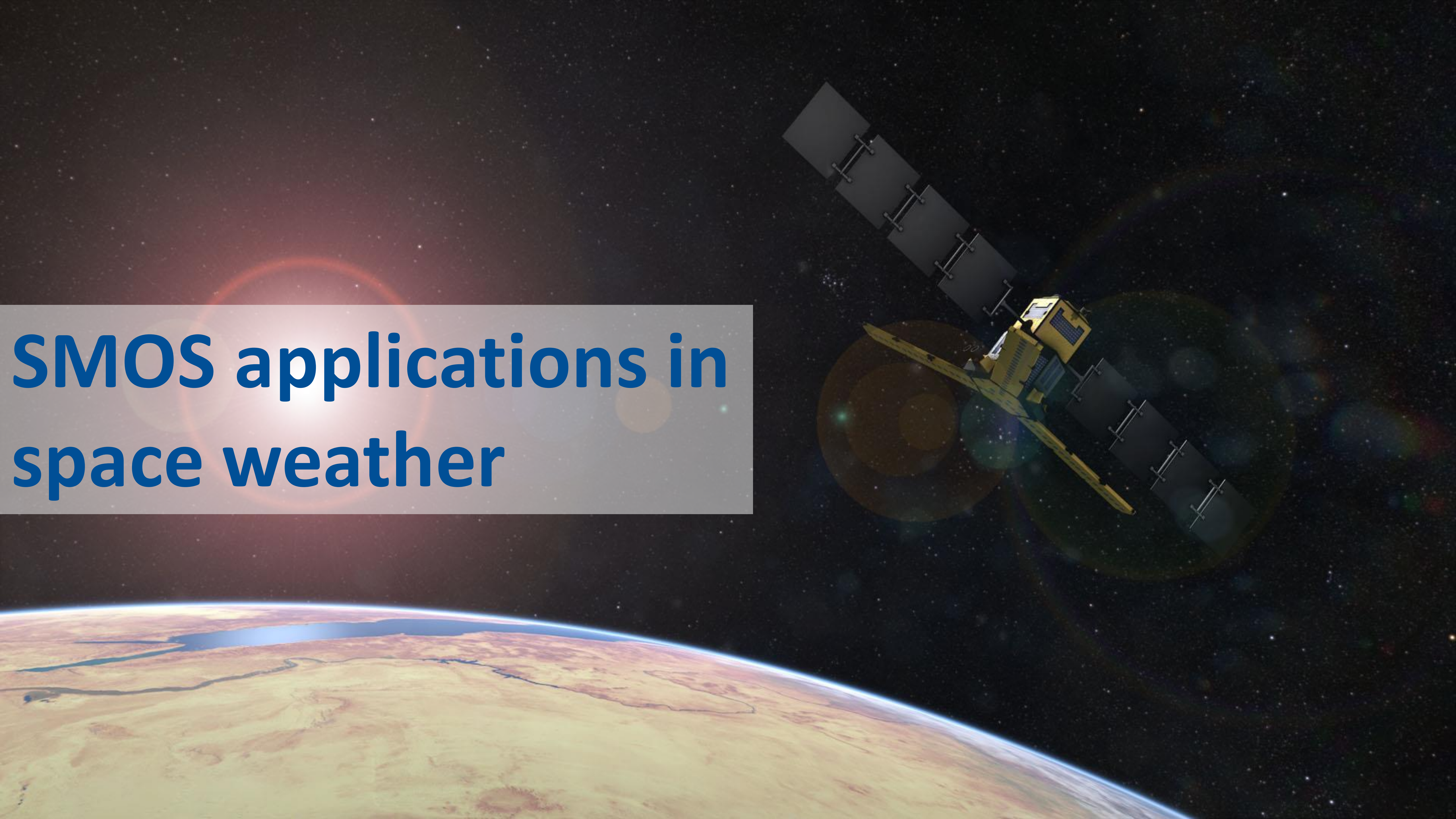
Calibration



Polarization



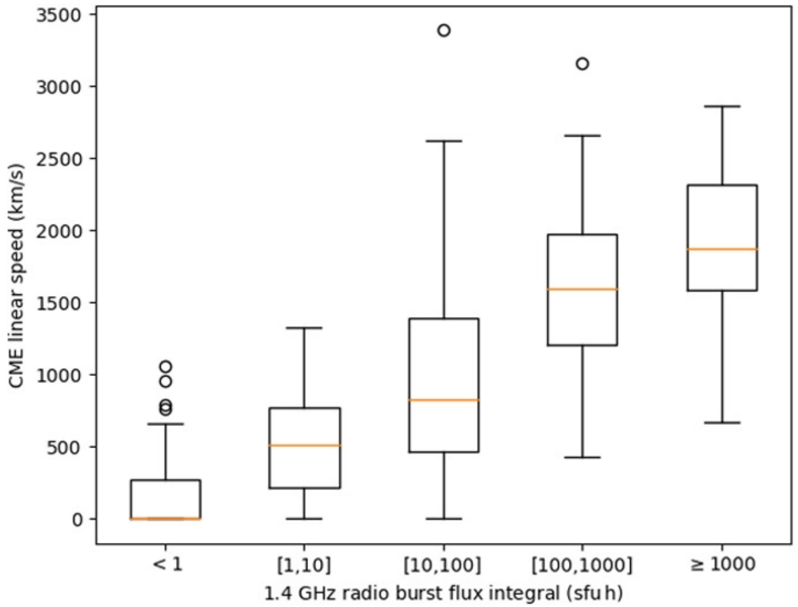
SMOS applications in space weather

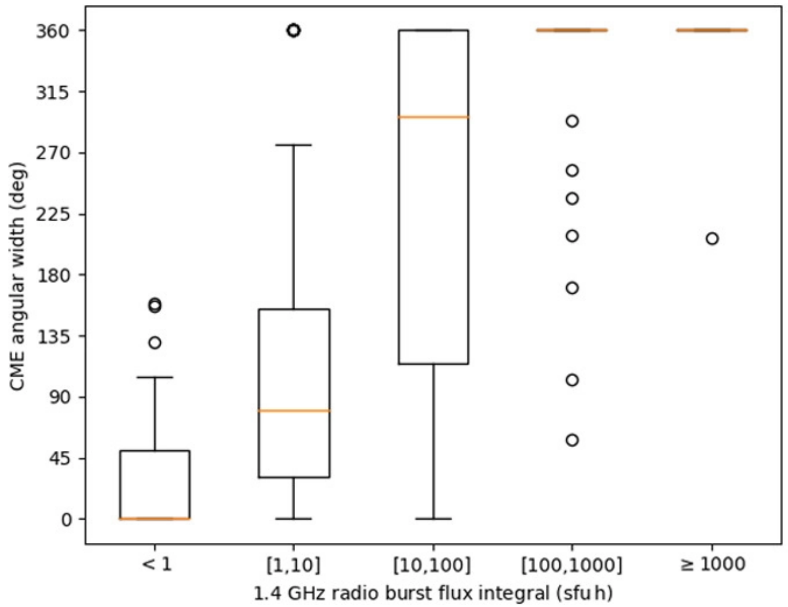


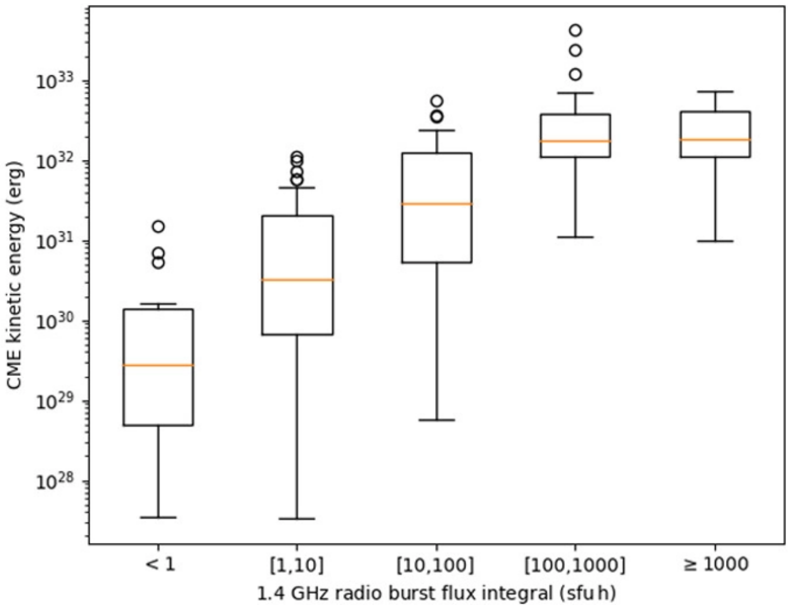
Monitoring of CME occurrence

Almost every flare with a 1.4 GHz SRB is related to a CME

The amount of flux released at 1.4 GHz correlates with the speed, angular width and kinetic energy of the CMEs

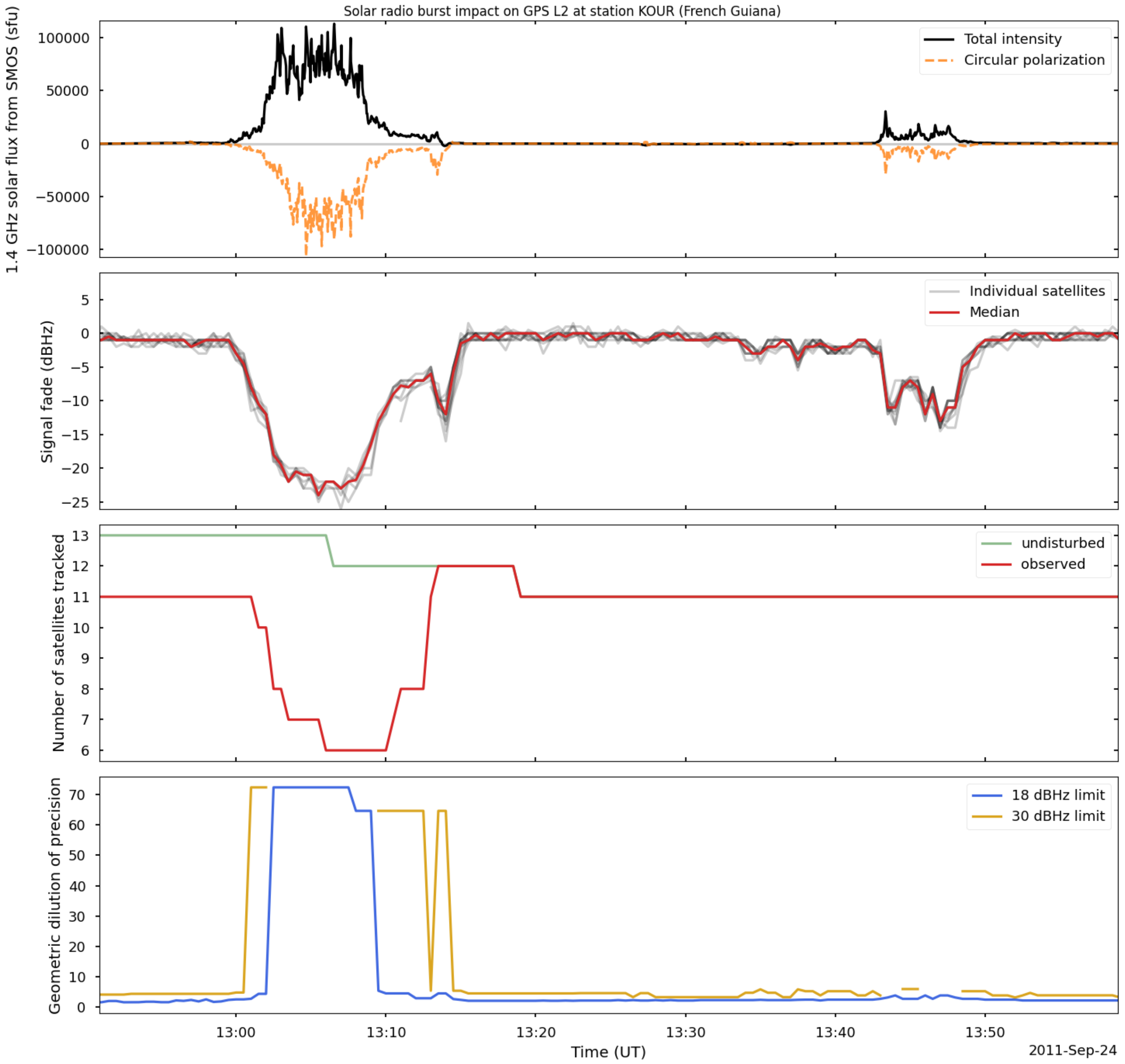


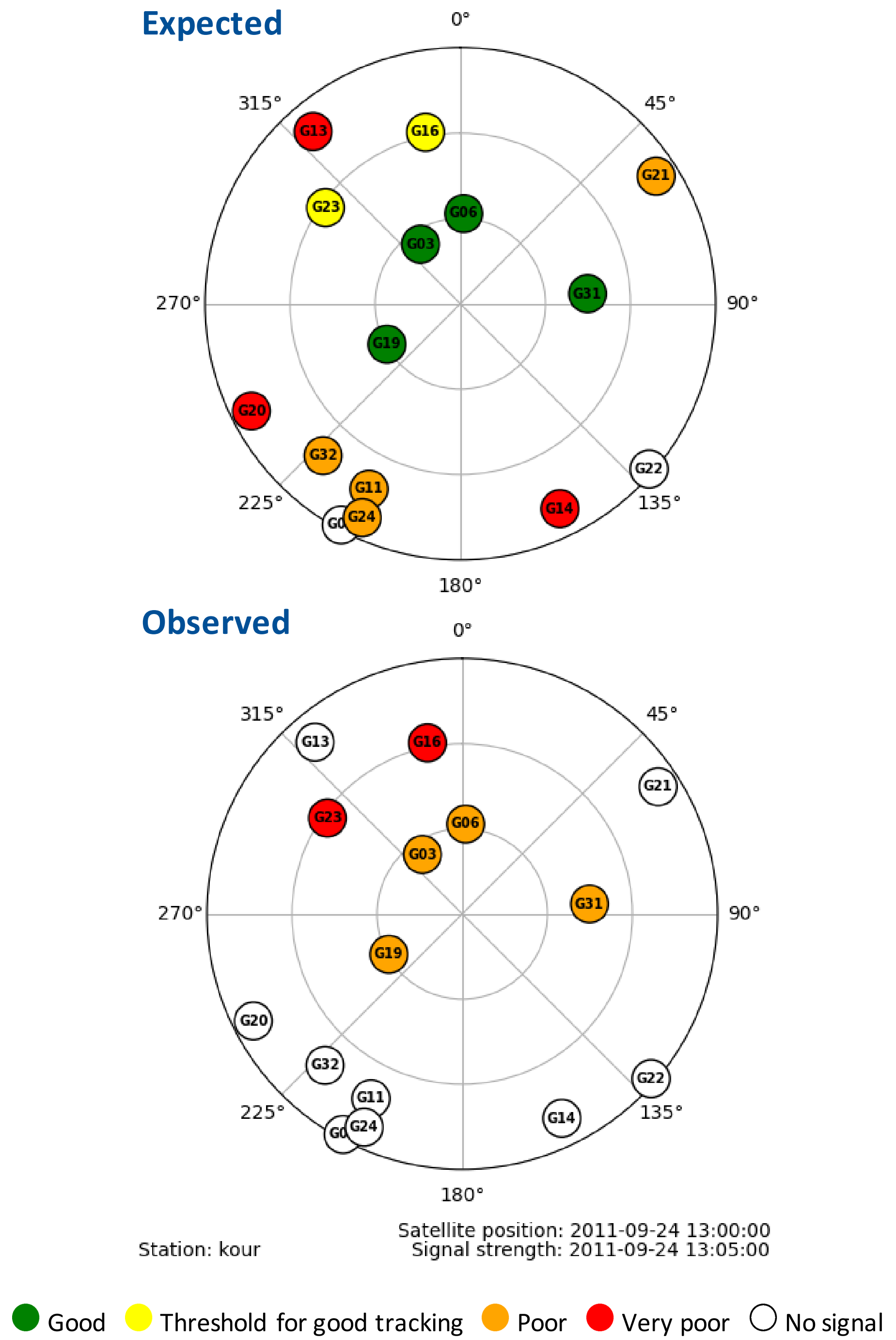




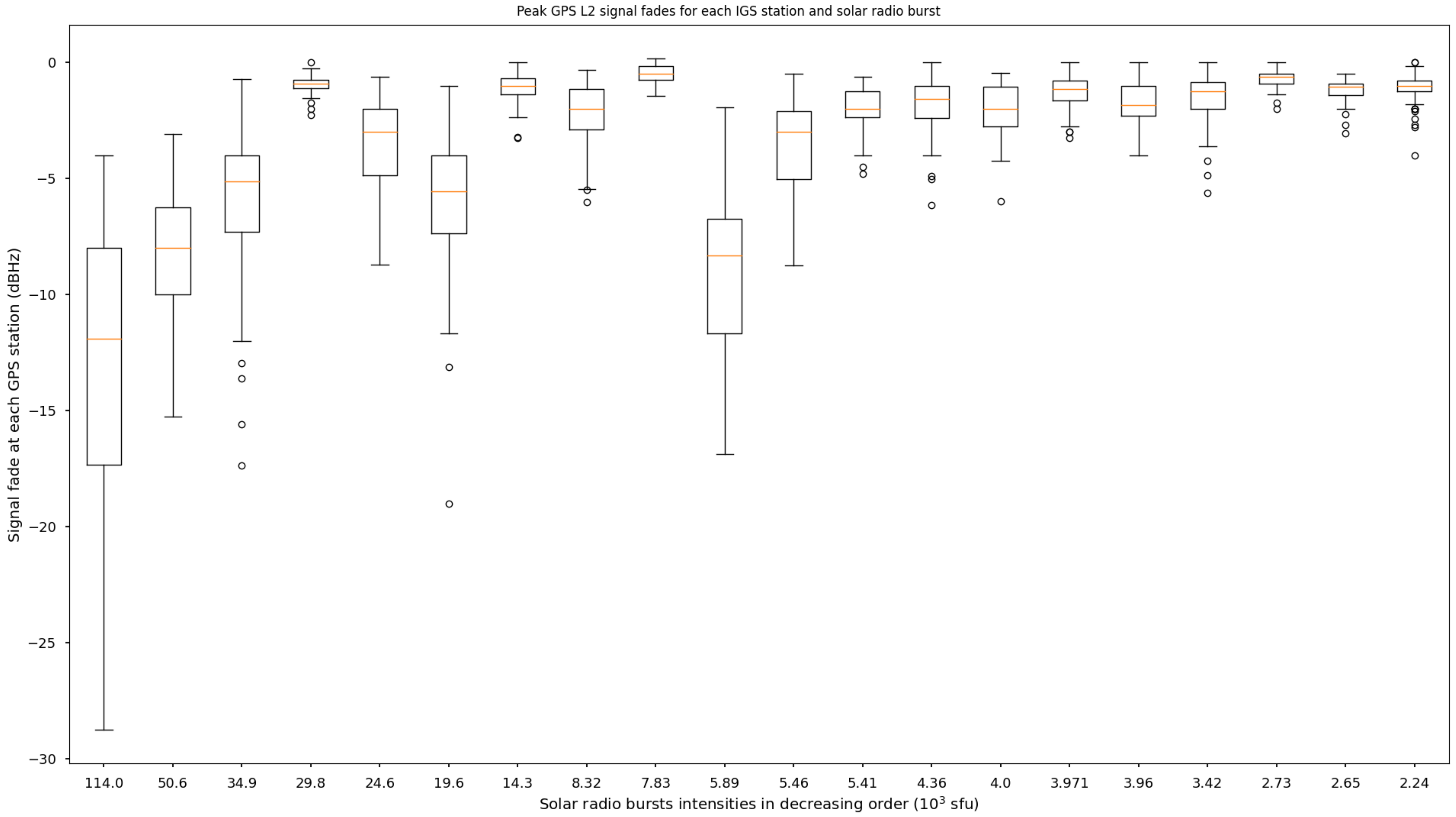
Flores-Soriano et al. (2021). https://doi.org/10.1029/2020SW002649
CME data from https://cdaw.gsfc.nasa.gov/CME_list/

SRB impact on GNSS - Example case

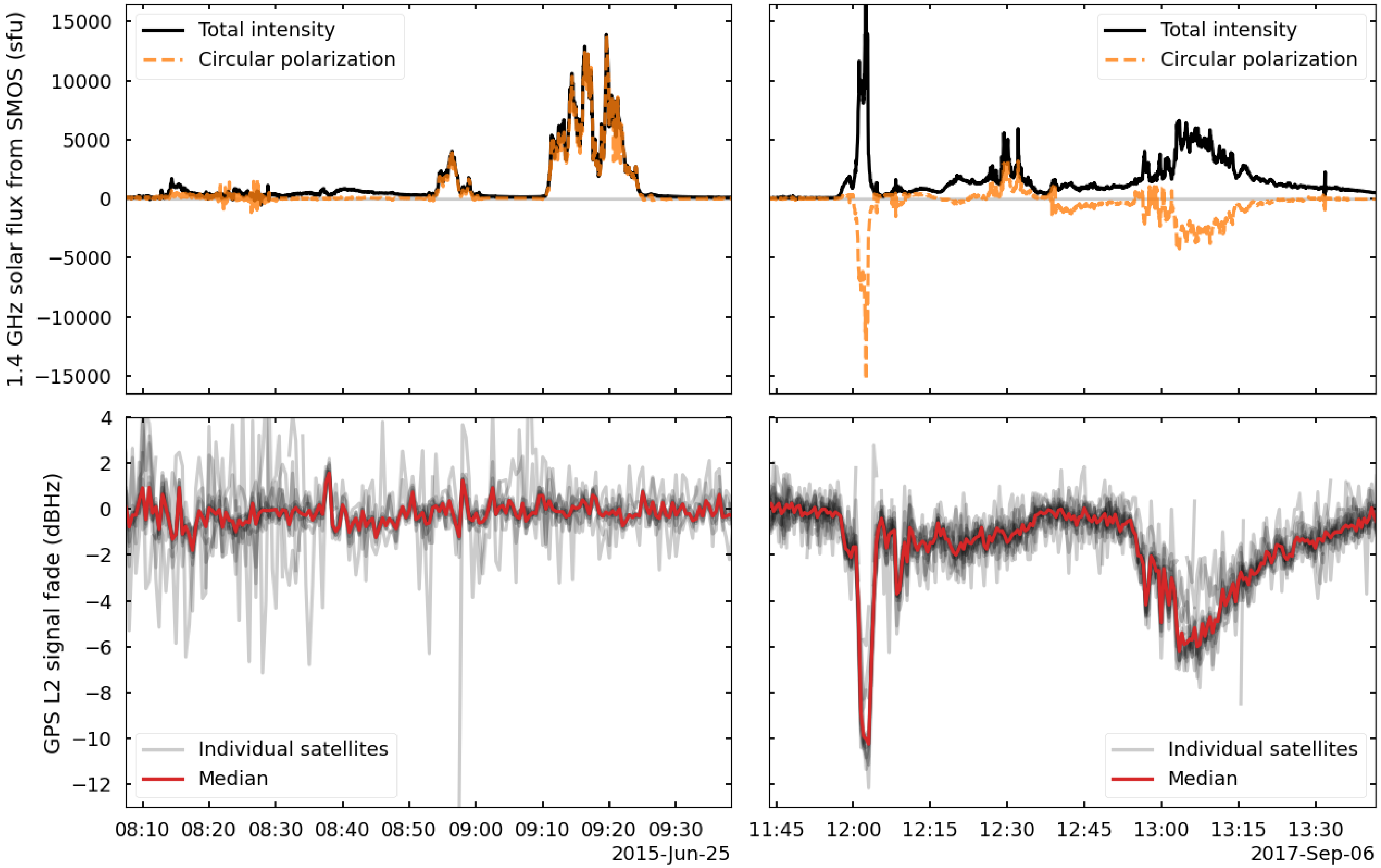




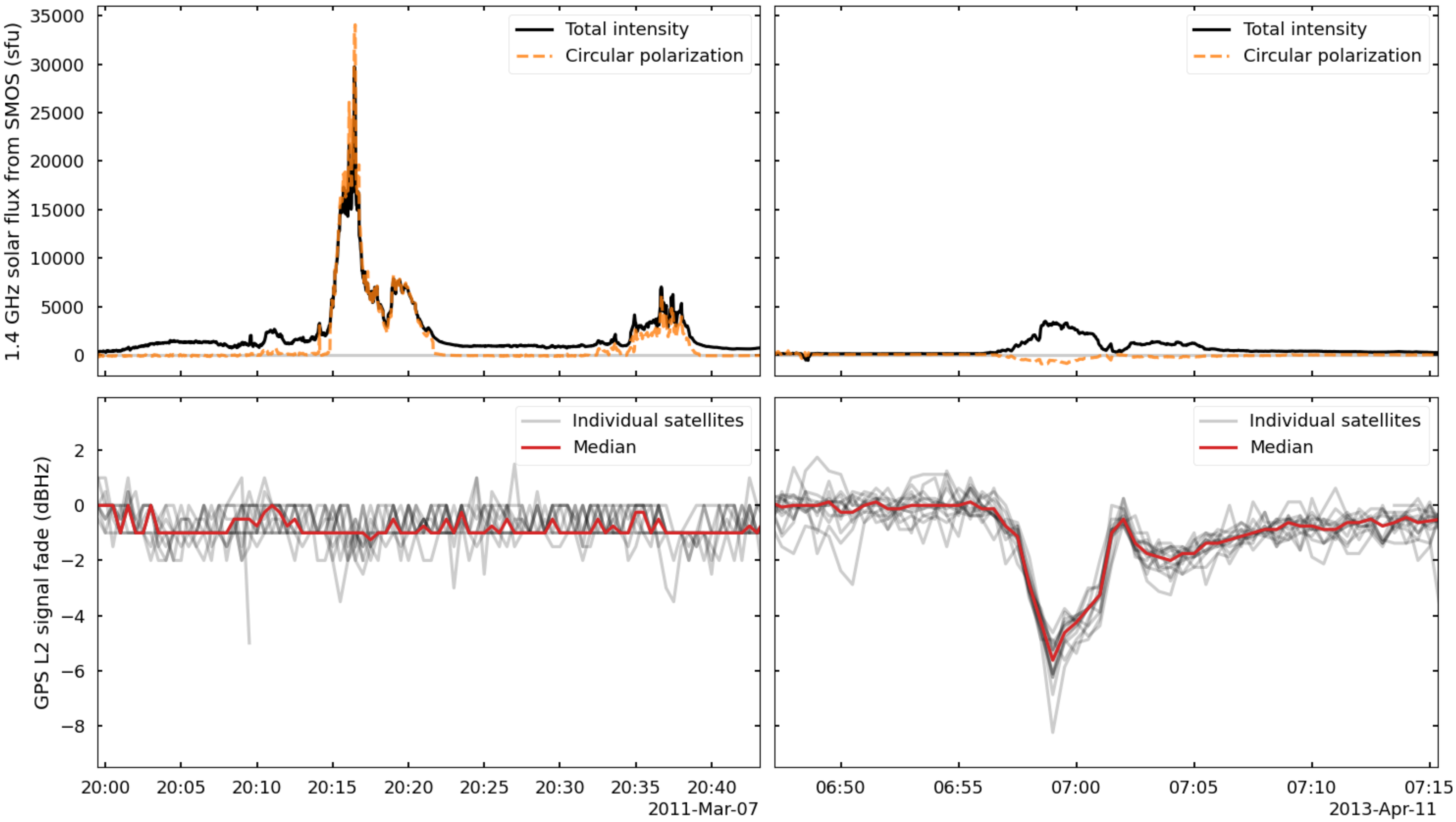
GPS L2 signal fade statistics during Solar Cycle 24



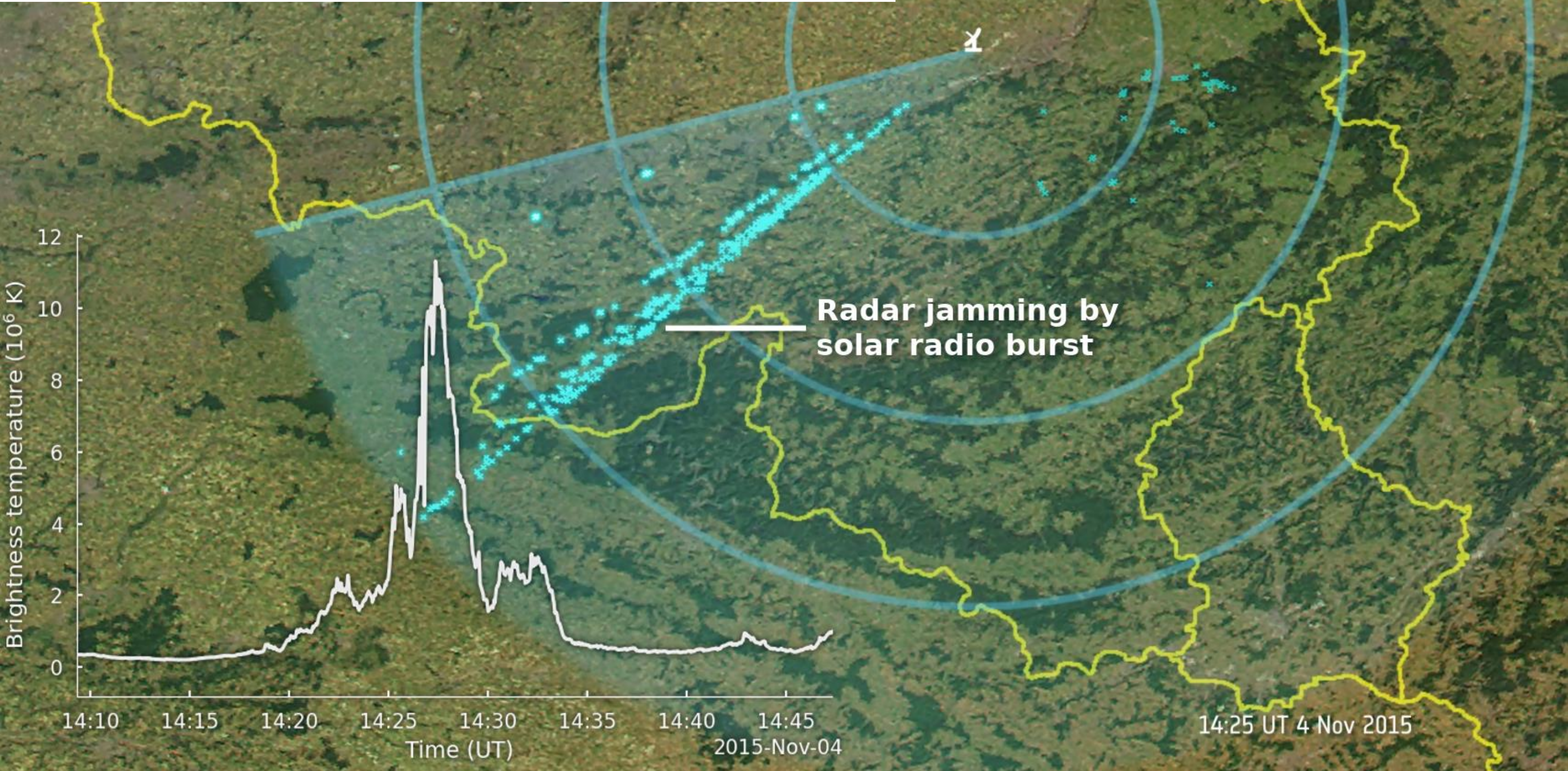
Importance of SRB polarization



Importance of SRB polarization



Impact on L-band air control radars



Radar image credits: **ESA/Planetary Visions. Adapted from Marqué et al. 2018. Space Weather Space Clim. 8, A42.**

Conclusions

SMOS 1.4 GHz solar observations:

- **How good?**
  - Comparable with dedicated instruments
  - Not affected by day/night cycle
- **What for?**
  - Full polarization studies of 1.4 GHz SRBs
  - Space weather monitoring and post-event analyses (CMEs, GNSS, radar...)
- **Why even bother?**
  - No other instrument now with similar functionality
  - Potential for near-real time 24h operations
  - Data since 2010

Thanks for your attention!!

Acknowledgements: We are very thankful to Deimos Space for their help processing the SMOS data. This work was supported by ESA contract “Synergic use of SMOS L1 Data in Sun Flare Detection and Analysis” and MINECO project AYA2016-80881-P. We acknowledge the use of data from GOES, STEREO, the RSTN and the SOHO LASCO CME Catalog from the CDAW Data Center.